

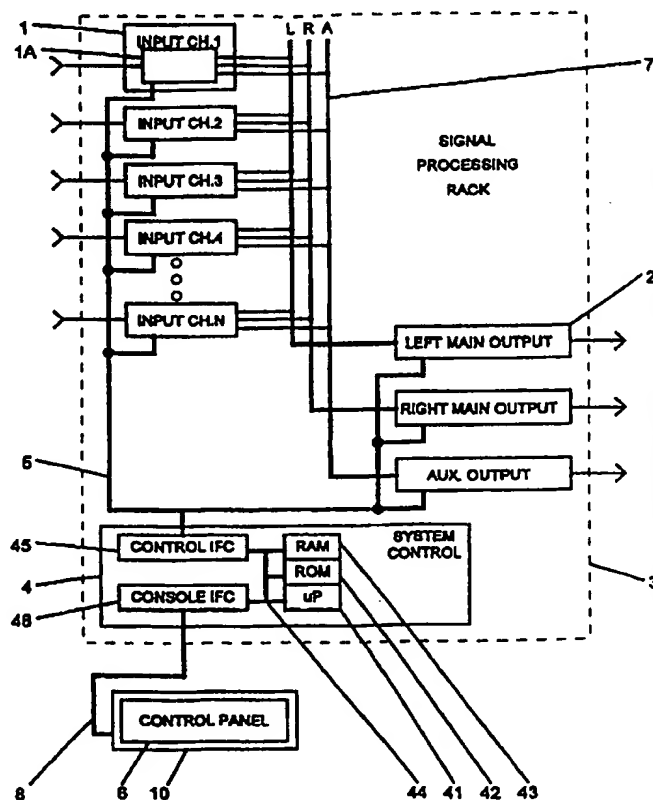


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/US99/01090 <b>(22) International Filing Date:</b> 19 January 1999 (19.01.99) <b>(30) Priority Data:</b> 09/009,235      20 January 1998 (20.01.98)      US <b>(71) Applicant:</b> SHOWCO, INC. [-/US]; 9029 Governors Row, Dallas, TX 75247 (US). <b>(72) Inventors:</b> POWERS, Timothy, Clay; 10505 Vinemont, Dallas, TX 75218 (US). PAGE, Howard, Churchil; 3744 Chatham Court Drive, Addison, TX 75244 (US). <b>(74) Agent:</b> JUDSON, David, H.; Hughes & Luce, L.L.P., Suite 2800, 1717 Main Street, Dallas, TX 75210 (US).		<b>(81) Designated States:</b> JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** SOUND MIXING CONSOLE WITH MASTER CONTROL SECTION**(57) Abstract**

A sound mixing control console, having a plurality of audio signal input channels, includes a master channel control section having a plurality of motorized knobs for adjusting various parameters of an audio signal. The master channel control section can be applied to any one of the audio signal input channels to allow an operator to adjust any of the various parameters of the signal including, for example: input gain, frequency equalization (tone controls), placement in stereo (pan), and output level. All of the aforementioned parameters for any single input channel can be store for later recall. The various stored parameters for each input channel correspond to positions of the various knobs provided in the master channel control section. When any single input channel is selected for adjustment and signal processing parameters have previously been stored for that channel, the motorized knobs of the master channel control section are driven quickly to positions that correspond to the stored parameters. The various parameters can then be re-adjusted as desired and stored either as a new group of settings or re-stored to replace the original group of settings.



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## SOUND MIXING CONSOLE WITH MASTER CONTROL SECTION

## ABSTRACT OF THE DISCLOSURE

## FIELD OF THE INVENTION

The present invention relates to sound mixing equipment,  
5 and particularly to motorized control features for a  
computerized sound mixing control console.

## DESCRIPTION OF RELATED ART

Automated sound mixing control consoles are known to  
include motorized faders for controlling the signal level of  
10 audio signals. The faders can be operated manually to set the  
desired signal levels, the movements of the faders being sensed,  
recorded and stored by electronic means. The faders can then be  
operated automatically by recalling stored data representing the  
movements of the faders, and applying the data to electronic  
15 motor controllers for driving the motorized faders. In this  
way, a complex mix of very many input channels can be rehearsed  
and recorded in parts, and then executed in its entirety.  
Automated sound mixing of this type is frequently employed for  
mixing a multi-track audio recording down to a stereo master  
20 recording, or for live mixing of a large concert event having  
very many input channels and plural stereo or monaural output  
mixes.

Motorized fader systems are shown, for example, in U.S.  
Patents No. 5,102,373; 5,122,720; and 5,293,102 to Martinson et  
25 al; in U.S. Patents No. 5,054,077; 5,060,272; and 5,239,458 to  
Suzuki. Alternatively, manual faders can be used to adjust the  
output amplitude of voltage-controlled amplifiers (VCAs), with  
the faders movements and positions being stored and data  
therefrom subsequently used to control the amplitude of VCAs as  
30 shown, for example, in U.S. Patents No. 3,982,071 to Weiss et al;  
4,885,792 to Christensen; 5,268,964 to Watts; and 5,402,501 to  
Silfvajt. As recognized by East in U.S. Patent No. 5,623,551,  
the provision of motorized faders solves the problem of there  
being more faders than can be effectively operated at one time  
35 by a single operator. Stavrou, in U.S. Patent No. 5,257,317;  
attempts to solve this problem by multiplexing a limited number

of faders and other input channel controls to a larger number of audio input channels.

Most sound mixing systems also provide circuits for controlling other signal parameters for each input channel thereof, including input gain and attenuation, panoramic (pan) control of stereo placement, frequency equalization filters, and auxiliary signal send level controls. Sophisticated sound mixing systems may also provide dynamic signal processing circuits for each input channel such as a compressor/limiter and/or a gate, with signal level and other parametric controls being provided therefor. Further, plural signal paths can be selected so that each input signal can be routed through a sub-master section in addition to or instead of being routing directly to a master output, and can further be routed through one or more sound effect imparting circuits such as a reverberation unit or other such circuit, and to one or more auxiliary outputs such as a monitor mix or a direct output for audio recording, with level controls and/or panoramic controls being provided for such routing assignments for each input channel.

Automated systems for controlling audio signal parameters and routing assignments as described above are shown, for example, in U.S. Patents No. 4,479,240 to McKinley Jr.; 4,635,288 to Stadius; 4,677,674 to Snyder; 4,879,751 to Franks; 4,993,073 to Sparkes; 5,206,913 to Sims; 5,212,733 to DeVitt; 5,257,317 to Silfvajt; and 5,444,676 to Balsamo. McKinley, Jr., for example, describes means for recording the positions of control elements used for setting various audio signal parameters, and further describes indicator means (a pair of LEDs) for showing an operator which way to adjust the control elements to manually restore them to a previously recorded position.

Franks and Silfvajt describe automated sound mixing systems including means for recording control element positions including routing switches, fader positions and control knob positions. Individual control knobs and faders for each input channel are provided with indicators to show an operator how to manually re-adjust the control elements to restore a sound

mixing system to a previously recorded state. Using these automated systems, complex mixes can be rehearsed and recorded in parts, including fader movements to set levels, control knob movements to adjust other signal parameters, and routing assignment switching, and then the complex mix can be executed in its entirety as required for studio mix-down recording or live concert performance.

In most prior consoles, especially for live concert applications, it is customary to provide all control knobs and switches for all physical channels, and to provide visual or aural feedback to the operator for manually adjusting the control knobs to restore a previously recorded console set-up. Editing a complex mix is therefore complicated by the necessity to restore control elements to their stored positions prior to manually adjusting signal parameters. The common technique employing LED indicators as feedback devices to an operator is cumbersome owing to the amount of time and manipulation required to re-set control knobs to the desired positions. Other feedback means, such as video display indications or voice synthesized feedback, are functionally equivalent to LED feedback and offer no substantial improvement. Rotary control knobs could be motorized and driven the same as motorized faders, but the number of knobs provided on a professional sound mixing console for large-scale applications requires a prohibitively weighty and expensive number of motorized control knob mechanisms.

Studio consoles are usually laid-out in a new and unfamiliar fashion such that a new user has no immediate familiarity with the layout of controls. Further, there is the temptation to which many have yielded to "simplify" operation of the console by providing only one rotary control element for signal parameter adjustment and providing switches for selecting the parameter to be adjusted. This is done because the technology exists to do it cheaply using a rotary encoder that provides delta rotation values irrespective of actual position of the knob, and facilitates the digital control techniques for multiplexing a single control knob over a matrix of channels and adjustable parameters. Current values of the adjustable

parameters are indicated by electronic display means. Live consoles tend to provide all knobs for all parameters of all channels, the knobs being active all of the time. Because of space requirements, all of the controls for a single input channel are laid-out in a vertical strip above the channel fader.

#### SUMMARY OF THE INVENTION

The preferred embodiments disclose a system and method for editing of previously stored console setups in a naturally understood manner, and to provide automated audio controls that respond in a naturally understood manner.

The preferred embodiments further disclose a sound mixing system comprising a sound mixing control console electronically coupled to audio signal processing circuits includes a plurality of audio signal input channels having adjustable input gain, adjustable frequency equalization in plural bands of audio frequencies, and adjustable signal level control; the system also including a plurality of output channels having adjustable output signal level control; the system providing electronic detection of moveable control element positions, the system further including an electronic memory sub-system; the sound mixing control console including plural front-panel control features for adjusting the signal levels of the input channels and of the output channels, and indicators showing the current state of input and output channel adjustable parameters; the console further including a master channel control section applicable to any one of the input channels of the sound mixing system; the master control section having a plurality of motorized control features for adjusting various parameters of an audio input signal, including at least input gain and frequency equalization; wherein the system can store plural set-ups of the control console in the electronic memory sub-system; each set-up including at least the input gain, frequency equalization parameters, and signal level of the input channels and further including signal levels of output channels; each of the plural set-ups being recallable to restore the audio signal processing parameters as set by the motorized control features of the console; the console further comprising a selection

control for each input channel that applies the master control section of the console to the selected input channel whereby selection of the input channel causes the electronic memory sub-system to read out stored signal processing parameters for that  
5 channel to a motor control sub-system of the master control section which then drives the motorized control features thereof to positions that correspond to the stored signal processing parameters.

Therefore, and in accordance with the exemplary embodiment,  
10 instead of providing every knob on every channel, with the knob being active in controlling its associated circuit parameter all of time, there is provided one set of control knobs, switches and associated indicators, and a selector switch associated with each group of individual input channel controls so that pressing  
15 the selector switch for a particular channel applies the one set of control knobs to the selected channel. The control knobs are motorized so that in the time it takes to turn one's attention from the channel selector switch, the knobs move quickly to positions corresponding to the current circuit parameters. The  
20 control knobs are then active for controlling their associated circuit parameters in a naturally understood manner, and may remain active until another input channel is selected.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic block diagram of a typical sound  
25 mixing system;

Figure 2 is a plan view of a console control surface according to the preferred embodiment;

Figure 3 is a detail view of input channel controls; and

Figure 4 is a detail view of a master channel control  
30 section of the console.

#### DETAILED DESCRIPTION

A sound mixing system as shown in Figure 1 includes plural input channels 1 for receiving audio frequency analog electrical signals from microphones or electrical musical instruments and  
35 the like, and further includes at least one but preferably plural output channels 2 for transmitting audio frequency analog

electrical signals. The input and output channels include the electronic signal processing circuits or units 1A which preferably comprise computer-controlled digital signal processor (DSP) devices and are preferably housed in an audio rack enclosure 3 which can be located in proximity to the signal sources, power source, and/or power amplifiers and loudspeakers of a sound reinforcement system. Alternatively, digitally-controlled analog audio circuits may be used for the input and output channels. The signal processing circuits could also be located in a control console housing 10 rather than in a separate enclosure.

A system control module 4 comprising a microprocessor 41, read-only memory (ROM) 42, random-access memory (RAM) 43, and associated control circuits, interconnected by address, data, and control buses 44, operates the input channel circuits and output channel circuits via control interface circuit 45 and a control bus 5. A console interface circuit 46 is provided to connect to a control panel 6, preferably enclosed in a separate control console 10 located remotely from the audio rack enclosure 3.

The input channel circuits 1 each provide plural adjustable signal parameters including input gain and frequency equalization (variable parameter filtering), routing assignments to one or more output channels, and signal level to the assigned output channel(s). The output channels each provide an audio bus 7 feeding in thereto for summing signals from the assigned input channels and provide adjustable output level. In a preferred embodiment, control elements for operating the sound mixing system are provided on the remote control console 10 connected to the audio rack enclosure 3 by an umbilical cable or snake 8.

The control console 10 shown in Figure 2 includes control elements for adjusting parameters associated with the input channels, including: a fader for adjusting the signal level applied to a main mixing bus; switches for selecting from among



a plurality of input connections and for assigning the signal to one of plural routing assignments; and control knobs for adjusting signal conditioning parameters such as input gain, amplitude compression or limiting, gating, frequency  
5 equalization, and for adjusting auxiliary signal levels to one or more auxiliary mixing buses. Control elements and associated indicators are arranged on the console 10 in groups, as follows: input channel controls A at the left-hand side of the console and input channel controls B at the right-hand side of the  
10 console; audio signal level meters C at the upper left-hand side and audio signal level meters D at the upper right-hand side; remote channel faders E at the lower left central part of the console; auxiliary master channel controls F at the left central part; a video display unit G at the upper central part; a  
15 console control section H at the lower right central part; a master channel control section J at the right central part of the console; and stereo master output controls K located at the right central part of the console adjacent the console control section H and master channel control sections J.

20 A fader is provided for each set of input channel controls, and is preferably motorized as shown, for example, by Suzuki in U.S. Patent No. 5,060,272; or by Martinson in U.S. Patents Nos. 5,102,373; 5,122,720; and 5,293,102. A SELECT or channel selector switch is provided for each of two audio input channels  
25 that can be operated by the set of controls, illustratively switching between audio input channel 1 or audio input channel 41. Indicators are provided for each set of input channel controls and are arranged to indicate signal routing status and signal level data.

30 Input channel control section A includes controls for a plurality of audio input channels, illustratively shown as 20 identical sets of controls. Input channel control section B illustratively includes 20 more identical sets of controls. Each set of controls illustratively includes two SELECT switches  
35 for selecting one of two audio input channels that can be

operated by the set of controls. The console then provides 40 sets of input channel controls for operating up to 80 audio input channels. As shown in **Figure 3**, each set of controls includes a motorized fader 11, two SELECT switches 12, 15, two multi-character electronic display units 13, 14, a SOLO switch 16, a MUTE switch 17, an assignable control knob 18, an LED bargraph meter 19, and an assortment of LED indicators 20 used for showing the current status of channel effects and routing assignments. When pressed, the SELECT switch 12 (or 15, depending upon which switch has been pressed) lights to indicate that the corresponding audio input channel has been selected.

Each set of input channel controls could easily be provided with more than two SELECT switches and multi-character displays for operating 120 or even 160 audio input channels with the 40 sets of input channel controls. Alternatively, each input channel control section A and B could be provided with more than 20 sets of input channel controls, for example 24 sets of controls per section, for operating 96, 144, or even 192 audio input channels using only 48 sets of controls. For convenience, however, only 40 sets of input channel controls are shown and only two SELECT switches are provided for each set. Additional audio input channels over and above the 80 channels provided for above are selected via features provided in a console control section H described below.

Audio signal level meters C and D are arranged to show the signal levels of auxiliary master buses, stereo master output buses, and monitor output buses. Remote fader section E provides 20 additional faders, each having two SELECT switches and two multi-character electronic displays, the remote faders being used for grouping certain input channels together to control their signal levels more easily.

Auxiliary master section F provides 16 sets of controls for operating 32 auxiliary master buses that can be used for a variety of purposes including plural monitor mixes or recording sends. A pair of switches is provided for selecting auxiliary master buses 1-16 or buses 17-32. Each pair of auxiliary master

controls can be operated in a stereo mode in which the odd-numbered auxiliary master becomes a left-channel master while the adjacent even-numbered master becomes a right-channel master. Each set of auxiliary master controls includes SELECT, SOLO, and MUTE switches, and further includes a multi-character electronic display for labeling the auxiliary master bus. Auxiliary master section F also includes additional controls and indicators for operating other console and system features including a test oscillator/noise generator, a talk-back system, monitor sends and the like.

A video display unit G is provided for interface with functions of a computer system used as the system control element of the sound mixing system; is used during a show, to display information such as a song list with notes, MIDI effects information, console set-up store and recall information; and can be used to graphically display current settings of a channel, user-specified default information, and special setting pages for advanced users.

Console control section H includes controls for operating the sound mixing system in different modes, including store and recall of console set-ups including the operational state of the faders, knobs, and switches provided thereon. The console control section H further includes switches for selecting audio input channels 1-80, 81-160, or 161-240 for operation by the 40 sets of input channel controls in sections A and B.

A stereo master control section K provides a pair of motorized faders for controlling the output level of a stereo master output mix, and further includes switches for selecting among a plurality of separate stereo master output mixes. Two, multi-character electronic displays are provided for labeling the stereo master output buses.

A master control section J as shown in Figure 4 includes a plurality of operators comprising a set of control knobs for adjusting input gain, frequency equalization and the like, which can be applied to any one of the various input channels in turn for adjusting signal conditioning parameters and auxiliary signal levels. Each of the control knobs of the master control

section is similarly motorized so that upon selection of a desired input channel by pressing the corresponding SELECT switch 12 or 15 on the set of input channel controls in section A or B, the various knobs in section J conform to positions that correspond to the current parameters or signal levels for the selected channel. The control system (CPU 41) of the preferred embodiment may recall from the electronic memory sub-system (RAM 43) plural set-ups of the control console. The various parameters and levels can then be adjusted manually and may also be stored in the electronic sub-system memory as an update or amendment of the original set-up or as part of a new set-up since the system provides electronic detection of movable control element positions. Each input channel can be adjusted in turn using a single set of motorized controls.

In a preferred embodiment as shown in Figure 4, knob 21 controls the input gain of a selected input channel and knob 22 controls panoramic placement in stereo. Knob 23 controls the signal level of a direct output. Control knobs 24 control various signal parameters related to the operation of a compressor/limiter and a gate, with associated switches for selecting compressor/limiter or gate control functions and indicators for showing the extent of compression/limiting or the threshold level of the gate. Control knobs 25 adjust the signal level (boost/cut), center frequency and band width of a parametric audio filter in a high band of audio frequencies. Control knobs 26 similarly adjust a parametric audio filter in a high-mid band while knobs 27 adjust a parametric audio filter in a low-mid band and knobs 28 adjust a parametric audio filter in a low band of audio frequencies. Control knob 29 adjusts the corner frequency of a high-pass audio filter. Control knobs 31 and 32 adjust signal level to a pair of auxiliary master buses, and can be operated in a stereo mode in which knob 31 controls the signal level while knob 32 controls a pan between left and right channels. Multi-character display units 30 and 33 can be used to label the auxiliary master buses. These auxiliary

master "sends" are repeated up the console so as to provide eight pairs of control knobs and associated displays and, when coupled with page select switches in a conventional manner, can be used to send a signal from a selected audio input channel to  
5 any of 32 auxiliary master buses.

While a preferred embodiment illustratively shows 40 motorized knobs in master control section J, it should be recognized that the basic concept can be practiced with fewer control knobs in a sound mixing system that provides fewer  
10 auxiliary sends, simpler audio filters, and/or simpler channel dynamics (compressor/limiter or gate). Alternatively, a greater number of motorized control knobs could be provided in a sound mixing system having more extensive signal processing features.

A principal advantage obtained hereby is that when an audio  
15 input channel is selected for adjustment of its various parameters by pressing a corresponding SELECT switch in input channel controls section A or B, the control knobs of master control section J quickly assume positions corresponding to the current values of circuit parameters controlled thereby, and are  
20 immediately responsive to manual manipulation for further adjustment. This arrangement eliminates any confusion as to what the current parameters are since they are indicated by the positions of the knobs. When the knobs are subsequently manipulated by the operator, the circuit parameters change  
25 immediately and can be stored in the electronic memory (RAM 43) as an edit to the current set-up or as part of a new set-up. As shown, a comparatively vast array of switches, indicators, and motorized control knobs is provided and can be applied to any audio input channel. The parameters controlled thereby are  
30 infrequently used, typically being adjusted for optimal performance within a given set-up and usually being adjusted one channel at a time in a rehearsal situation in which all audio input channels except the one being adjusted can be muted. There is, therefore, no particular necessity for having that  
35 vast array of controls present and active on all 40 sets of input channel controls. This being the case, it now becomes feasible to motorize all of the control knobs corresponding to

these audio signal parameters since only one set of knobs is required regardless of the total number of audio input channels supported by the sound mixing system. Further, if adjustment of any of the audio signal parameters controlled by the knobs of master control section J is required during a live concert performance, access to the desired signal parameters is easily obtained simply by pressing the SELECT switch of the corresponding input channel control and turning the appropriate control knobs, without any tedious multi-level menu-based selection process such as is commonly found in advanced, digitally controlled studio consoles and without any counter-intuitive manipulation of the control knob to reset its position to one that corresponds to the present value of the signal parameter.

In accordance with another aspect of the preferred embodiment, the features of the control console, and especially the features of master control section J, are laid-out in a naturally understood arrangement that groups the control knobs according to their function. Audio filter controls 25-29 are laid-out in a vertically arranged strip, as are channel dynamics control knobs 24. Auxiliary master send controls 30-33 are grouped in pairs and laid-out in vertically arranged strips. Input control knobs 21-23 are grouped together at the top of the console between the video display G and the meter section D so that critical controls such as input gain 21 and pan 22, and their associated switches, are easily accessible. In this way, a new user is immediately familiar with the layout of controls on this new sound mixing control console, and does not experience the effects of a "learning curve" such as encountered with other recent sound mixing control consoles, especially the consoles for controlling digital audio systems found in recording studios and the like. This is a special advantage for large-scale, "live" concert sound mixing applications, in which there is frequently no opportunity for a sound mixing engineer to become familiar with the layout of a new control console.

Those skilled in the art will appreciate that various substitutions, omissions, modifications and changes may be made

in the method and apparatus of the present invention without departing from the scope or spirit thereof. Accordingly, it is intended that the forgoing description be considered merely exemplary of the present invention and not a limitation thereof.

- 5 Therefore, the above-described embodiments are merely examples of how the invention may be carried out and other ways may also be possible which are within the scope of the following claims.

## WE CLAIM:

1. A sound mixing control console comprising:

a plurality of input control channels having signal processing functions applied thereto by a plurality of signal processing units;

a plurality of operators which can be driven both manually and by motors and each of said plurality of operators corresponding to a plurality of variable parameters of said signal processing functions;

a plurality of channel selectors for selecting said input channels to be controlled in dependence upon operation of said plurality of operators;

memory for storing operation positions of said operators;

control system for recalling operation position information stored in said memory with respect to the input channel selected by said channel selectors and for positioning said operators to said position; and

said signal processing units adjusting the input signal in correspondence to the positions of said operators with respect to the input channel selected by one of said plurality of channel selectors.

2. The system of claim 1,

wherein said plurality of operators are laid out in vertically arranged strips.

3. The system of claim 1,

wherein said plurality of operators are grouped according to their function.

4. The system of claim 1,

wherein said plurality of operators are grouped in pairs and laid-out in vertically arranged strips.

5. The system of claim 1,



wherein the signal processing units are computer-controlled digital signal processor devices.

6. The system of claim 1,

5 wherein the signal processing units are digitally-controlled analog audio circuits.

7. The system of claim 1,

10 the memory storing operation positions for each of said plurality of input channels.

8. The system of claim 1,

15 wherein said plurality of variable parameters include input gain and frequency equalization.

9. The system of claim 1, further comprising:

20 display for indicating which of said plurality of input channels is selected to be controlled by said plurality of operators.

10. A sound mixing control console comprising:

a plurality of input control channels having signal processing functions applied thereto by a signal processing means;

25 a plurality of operators corresponding to a plurality of variable parameters of said signal processing functions;

means for selecting said input channels to be controlled in dependence upon operation of said plurality of operators;

30 means for storing operation positions of said operators;

means for recalling operation position information stored in said memory with respect to the input channel selected by said channel selection means and for positioning said operators to said position; and

35 said signal processing means adjusting the input signal in correspondence to the positions of said operators with

respect to the input channel selected by one of said plurality of channel selectors.

11. A method of mixing sound comprising:

- 5           selecting one of a plurality of input control channels to be controlled in dependence upon operation of a plurality of operators;
- automatically recalling operation position information stored in a memory with respect to the input channel selected
- 10          and positioning said operators to said position; and
- adjusting the input signal corresponding to the position of said plurality of operators with respect to the channel selected by a plurality of channel selectors.

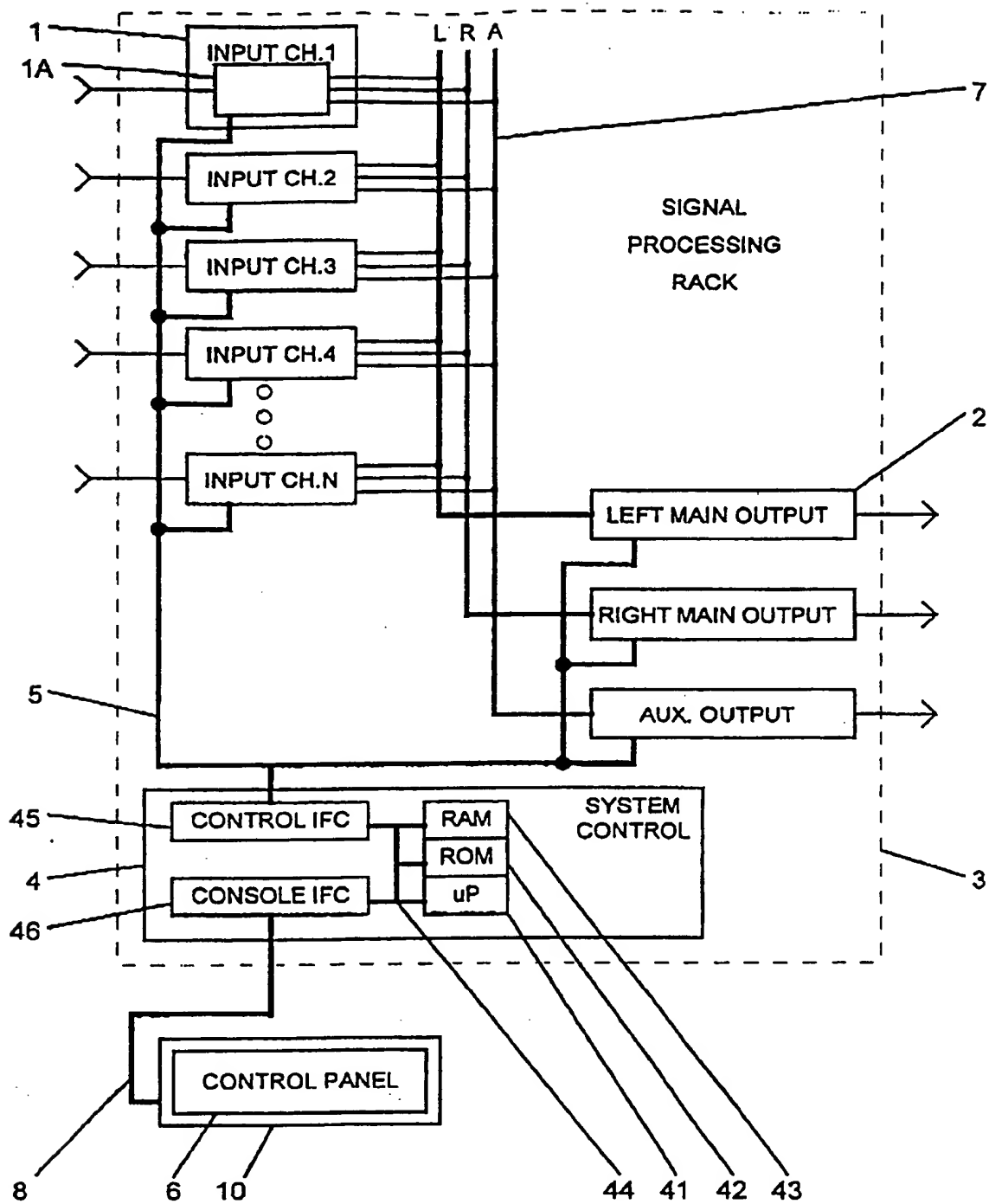


Fig.1

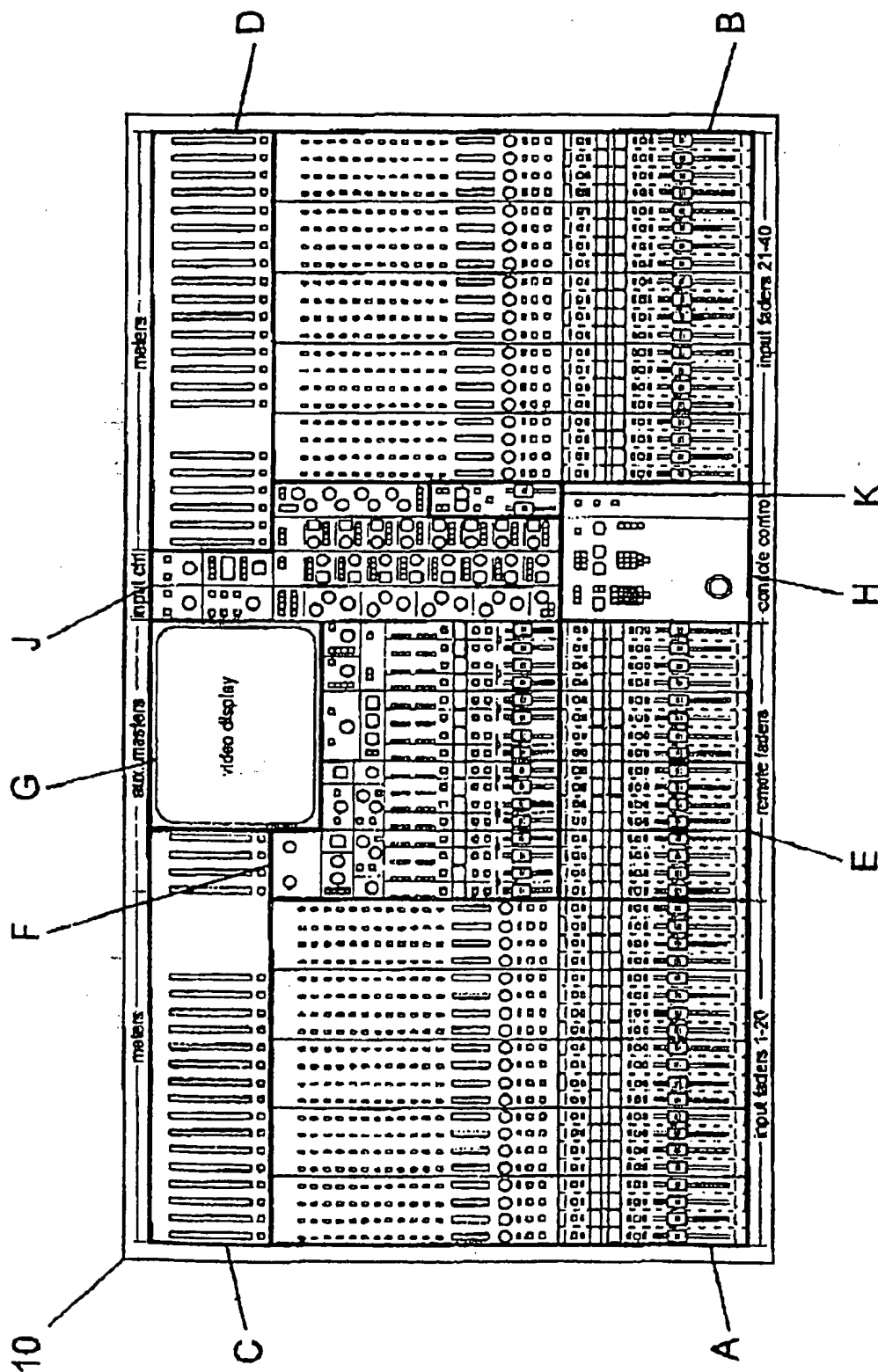


Fig. 2

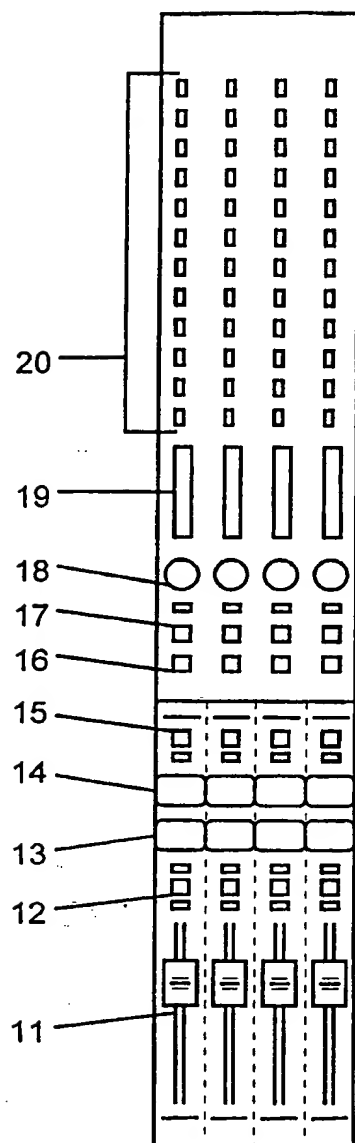


Fig. 3

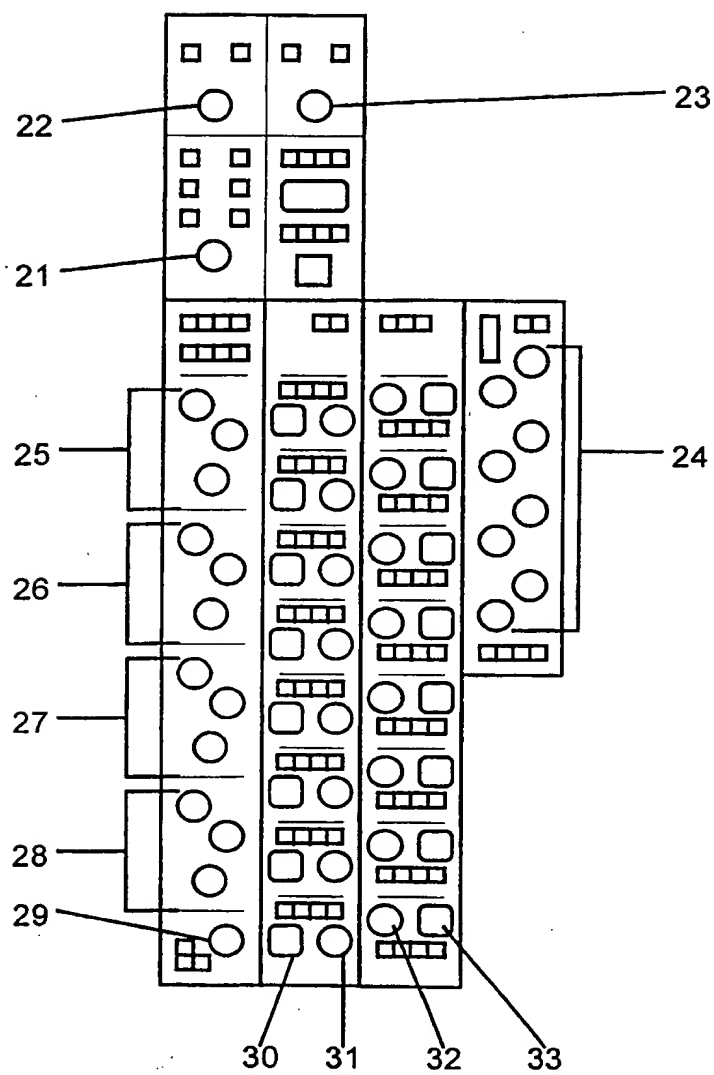


Fig. 4

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/01090

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04H7/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 879 751 A (FRANKS NICHOLAS ET AL) 7 November 1989 see abstract see column 2, line 33 - column 4, line 43 see claim 8 see figures 1,2,4,7 ---	1-11
A	US 5 402 501 A (SILFVAJT SCOTT W ET AL) 28 March 1995 see abstract see column 2, line 58 - column 3, line 46 see column 14, line 62 - column 15, line 68 see figures 1,2,5,9 --- -/--	1-11

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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# INTERNATIONAL SEARCH REPORT

Inter. onal Application No

PCT/US 99/01090

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>GB 2 299 492 A (SONY UK LTD)  2 October 1996  see abstract  see page 1, line 3 - page 4, line 18  see figures 3,4,6</p> <p>-----</p>	1-11

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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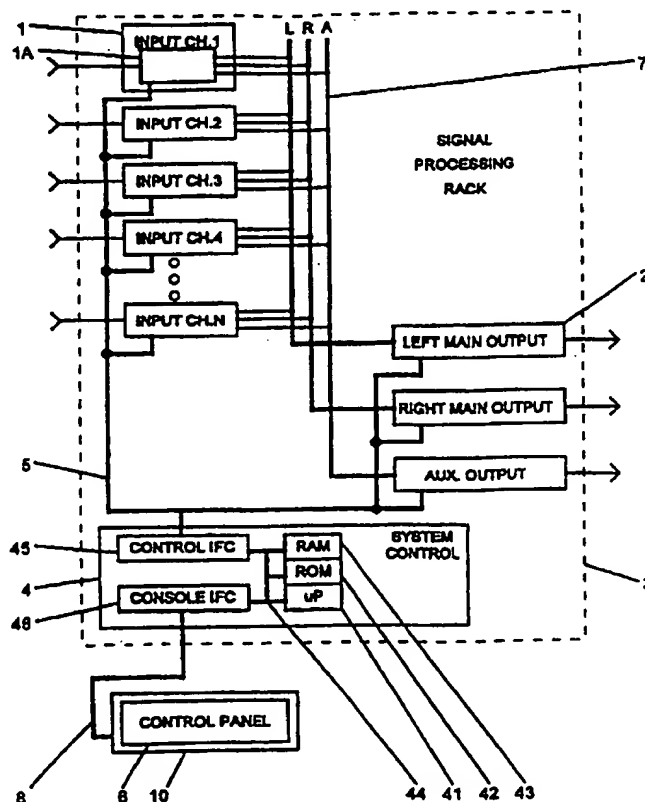
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(21) International Application Number: PCT/US99/01090 (22) International Filing Date: 19 January 1999 (19.01.99) (30) Priority Data: 09/009,235          20 January 1998 (20.01.98)          US (71) Applicant: SHOWCO, INC. [US/US]; 9029 Governors Row, Dallas, TX 75247 (US). (72) Inventors: POWERS, Timothy, Clay; 10505 Vinemont, Dallas, TX 75218 (US). PAGE, Howard, Churchil; 3744 Chatham Court Drive, Addison, TX 75244 (US). (74) Agent: JUDSON, David, H.; Hughes & Luce, L.L.P., Suite 2800, 1717 Main Street, Dallas, TX 75210 (US).			(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.          Before the expiration of the time limit for amending the          claims and to be republished in the event of the receipt of          amendments.</i>

(54) Title: SOUND MIXING CONSOLE WITH MASTER CONTROL SECTION

(57) Abstract

A sound mixing control console, having a plurality of audio signal input channels, includes a master channel control section having a plurality of motorized knobs for adjusting various parameters of an audio signal. The master channel control section can be applied to any one of the audio signal input channels to allow an operator to adjust any of the various parameters of the signal including, for example: input gain, frequency equalization (tone controls), placement in stereo (pan), and output level. All of the aforementioned parameters for any single input channel can be store for later recall. The various stored parameters for each input channel correspond to positions of the various knobs provided in the master channel control section. When any single input channel is selected for adjustment and signal processing parameters have previously been stored for that channel, the motorized knobs of the master channel control section are driven quickly to positions that correspond to the stored parameters. The various parameters can then be re-adjusted as desired and stored either as a new group of settings or re-stored to replace the original group of settings.



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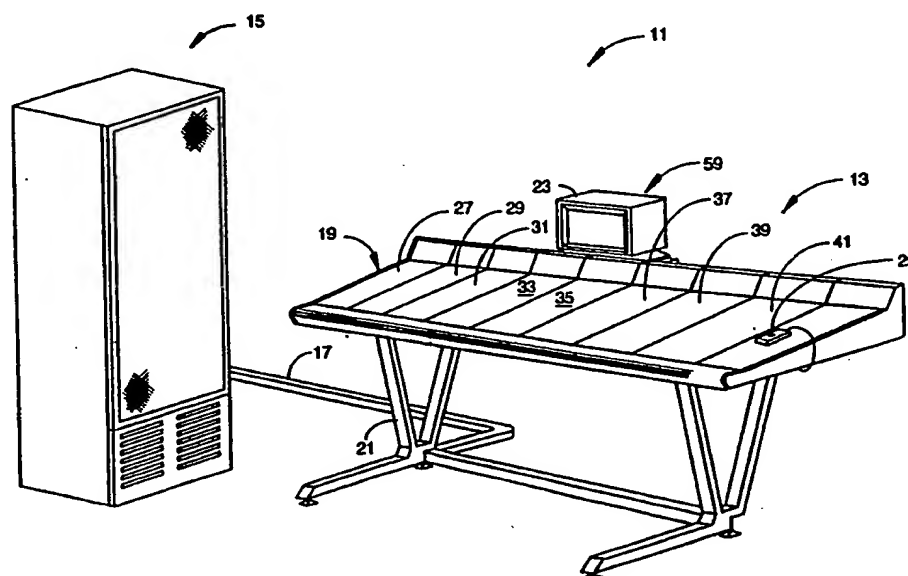
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<b>(21) International Application Number:</b> PCT/US92/06229 <b>(22) International Filing Date:</b> 27 July 1992 (27.07.92)  <b>(30) Priority data:</b> 738,586                      31 July 1991 (31.07.91)                      US  <b>(71) Applicant:</b> EUPHONIX, INC. [US/US]; 220 Portage Ave., Palo Alto, CA 94306-2242 (US).  <b>(72) Inventors:</b> SILFVAST, Scott, W. ; 1300 Rhode Island, San Francisco, CA (US). REIF, Adam, W. ; 662 Mountain View Ave., Mountain View, CA 94040 (US). SILFVAST, Rober, D. ; 309 Cowper St., Palo Alto, CA 94301 (US). KALMAN, Andrew, E. ; P.O. Box 7045, Stanford, CA 94309 (US). KADOTA, Russ, K. ; 1248 Harriet St., Palo Alto, CA 94301 (US).		<b>(74) Agent:</b> SMITH, Joseph, H. ; 4410 Casa Madeira Lane, San Jose, CA 95127 (US).  <b>(81) Designated States:</b> JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, MC, NL, SE).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** AUTOMATED AUDIO MIXER**(57) Abstract**

A production mix controller (11) for processing and mixing audio signals has a control console (19) separate from an audio mainframe (15). All audio signals to be mixed are confined to the audio mainframe (15) and the control console (19) has channels of input devices (27, 29, 31, 33, 35, 39, 41) providing low-voltage input control signals, which are converted to digital signals and stored by a microprocessor-based control system (59). The control system (59) includes menu selectable functions for setting control modes and routing signals. Digitally controlled analog audio control devices (45, 47, 49, 51) at the audio mainframe (15) are controlled by digital signals retrieved from memory and communicated to the audio mainframe (15) making the system software controllable. The invention includes functions for block copying arrays of input settings, and facility for storing and retrieving digital snapshots of entire configurations. Input controls are arrayed in channels, and channels are arranged in removable pod modules for modularity.

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## Automated Audio Mixer

### Field of the Invention

The present invention is in the area of instruments and systems for managing and mixing audio input for production purposes, such as recordings, and pertains particularly to computer automation of such systems.

### Background of the Invention

Audio production for television, video, film, and recorded music sales is a large and growing enterprise, and is the foundation of much of the entertainment industry. Automation in the form of computerization is becoming more and more important as the basis of technical advances in this industry, to provide ability to mix and process more sophisticated and more voluminous audio input, and to provide more flexibility in output. Computerization is also seen as a requirement for cost-effective competition. Manual instruments, systems, and techniques are, by comparison, increasingly more expensive to use.

The basic instrument of audio production is the production mixing console, a workstation presenting an interface to a sound engineer through which he or she may condition multiple channels of audio input, and mix the conditioned results into mono or stereo outputs for direct broadcast or for recording. A production mixing console, hereinafter a mixer, typically presents arrays of input devices, such as switches, knobs, and "faders", for an operator to set to condition and route audio signals. A fader is typically a slide rheostat through which an amplitude may be adjusted as a result of the linear position of the input lever relative to a track.

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Mixers typically route audio input signals to individual channels, and each such channel has a repetitive layout of switches, knobs, and faders. For example, a single channel can have more than one input, such as a microphone input and an input from an instrument, a group of instruments, or a tape. Using the controls on a mixer an engineer can select microphone, line, and tape inputs, route the inputs to signal conditioning devices like faders and equalizers, and mix and route the output from the conditioning devices as well. There is typically a selective ability to monitor audio signals, such as by headphones, and often a microphone for talkback by the sound engineer operating the console.

Audio mixing, especially with digital techniques and computer control, is historically a rather recent development. When rock-and-roll music was first introduced there was no such device as a mixer. In the fifties, recording was done by direct input. Modern mixing was initiated about the time of the appearance of the Beatles, and the first units were highly individualistic. Through the sixties and early seventies direct audio mixers continued to be developed, and continued to be relatively small units with a few channels and were very unique in layout. In the mid-seventies standards began to appear, especially relative to layout of switches, rotary potentiometers, and faders. With a standard layout it became possible for a sound engineer to go from one studio to another, and take over the functions comfortably.

In the early development and well into the late seventies, mixers were completely manual. The audio signals were routed to the mixer, and directly through the switches, pots, and faders. As a result, there were some definite limitations and problems. For example, with the audio signals routed directly through the switching and signal processing devices, it was

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necessary that heavy duty, low noise devices be developed. Without ultra-high quality devices, contacts, rheostat slides, and the like produce unwanted clicks and other noises that are incorporated into the audio signals.

Another difficulty is that the devices have to be used a great deal. During production sessions an engineer is constantly making changes in settings of many devices, and, just like any other expensive equipment, the mixer has to be used a great deal to justify its cost. Still another problem is that with audio signals routed through the console, especially in the event of many channels in use for multiple inputs, there is a lot of opportunity for cross-talk, meaning mixing of signals not meant to be mixed.

In addition to the problems described above, there are also particular limitations relative to manual consoles. One is simply size. As the number of inputs increases, the necessity for additional channels also increases, and the size of the console layout increases as well. Consoles quickly become unwieldy, and an engineer has to move up and down a wide console to make adjustments.

Yet another limitation is that manual settings have to be made for every session, and adjusted. It is quite difficult to duplicate favorite settings. An engineer using a manual console must make notes and diagrams of preferred settings, and adjust manual controls to suit. Even when settings are recorded, it is very difficult to reproduce them exactly on a single console, much less on a different console. With a manual console, sound engineering is very much an art and very little a science.

In the 1980's automation began to appear in professional recording studios. The first efforts were patchwork devices for automating manual console functions, and even today many

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automated consoles are analog audio consoles with digital equipment adapted to existing devices. Part of the reason for this is the expense of analog audio equipment, and the natural reluctance of manufacturers to scrap usable and saleable devices in favor of complete new designs. So there has been a tendency to automate in an incremental fashion, leaving some functions manual, and in almost all cases, continuing to route audio signals through the console.

What is needed is a console designed to separate the audio from the control console, with all controlled audio routed and processed in a completely separate area. Such a system needs to be computer controlled and software based, "remembering" device settings for future use, and taking advantage of digital processing techniques, such as displaying equalizer curves and allowing software set up and configuration.

#### Summary of the Invention

A mix controller is provided by the present invention for processing and mixing audio signals, including an audio mainframe for receiving, processing and mixing, and outputting the audio signals through digitally controllable analog audio control devices contained in the audio mainframe. There is a console for inputting analog electric control signals and for displaying control status and signal characteristics, including signal routing. The invention also includes a microprocessor-based control system coupled to the console for receiving the analog electric control signals, converting them to digital data, storing and retrieving the data, and for controlling the transfer of the data between the console and the audio mainframe. In addition there is a data communication sub-



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system connecting the audio mainframe and the console for carrying the digital data. The digitally controllable analog audio control devices in the audio mainframe respond to the data converted to digital form from the analog electric control signals.

Manually settable analog electric input devices and lightable displays for displaying control status and signal characteristics are grouped on the control console in control blocks with each control block corresponding to one of the digitally controllable analog audio control devices in the audio mainframe. Control blocks are arranged in channel arrays, and channel arrays are grouped into removable pod modules, with each pod module having a microprocessor for control function and a RAM memory unit for storing digital data. There are additionally bar graph meters on the console for displaying data.

In the preferred embodiment each removable pod module connects by a separate digital communication cable to a control module in the audio mainframe, with each control block on the pod module corresponding to one of the digitally controllable analog audio control modules.

A method is provided in the invention for calling attention to a control block by pressing a block attention key at the control block, selecting control functions from the menu, entering data to control routing and set control modes, and displaying settings at displays at the control block. Another method is provided for copying control block settings from one control block to another, and yet another for storing and recalling complete console configurations.

The invention provides a unique mixer console with an absolute minimum of crosstalk or noise contributed by control devices. Also, the use of low voltage analog electric input

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devices coupled with conversion to digital control signals tends to maximize reliability and durability while minimizing cost. Multiple input modules each with a control microprocessor provides for off line repair and maximum up time for the mixer system. The conversion of input signals to digital form and storing the digital equivalents in RAM memory makes the system software controllable.

### Brief Description of the Drawings

Fig. 1 is a perspective view of a mixing system according to a preferred embodiment of the invention.

Fig. 2 is a block diagram of the system of the preferred embodiment to illustrate the physical architecture of the system.

Fig. 3A is a plan view of input devices arranged in a single input-output channel.

Fig. 3B is an enlargement of a digital bargraph meter from Fig. 3A.

Fig. 3C is an enlargement of input controls for a programmable gain amplifier from Fig. 3A.

Fig. 3D is an enlargement of control inputs from Fig. 3A for a pair of auxiliary sends.

Fig. 3E is an enlargement of a fader from Fig. 3A.

Fig. 4 shows a pod module removed from a pod bay in the preferred embodiment.

Fig. 5A is a plan view of a master module in the preferred embodiment.

Fig. 5B is a view of just the Macro Section of the Master Module.

Fig. 5C is a view of just the Master Section of the Master Module.

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Fig. 5D is a view of just the Command Section of the Master Module.

Fig. 6 is a block diagram of the control architecture of the system in the preferred embodiment.

Fig. 7A is a partial diagram of a hierarchical menu organization for the control system.

Fig. 7B is a diagram showing additional menus.

Fig. 7C is a diagram showing yet additional menus.

Fig. 8A shows a display of a menu accessed from a block attention key.

Fig. 8B shows a display after assigning inputs to a fader in a channel on the console.

Fig. 9 is a schematic diagram of control signal routing from input devices to controlled audio processing devices.

Fig. 10A shows a block copy function relative to RAM memory space.

Fig. 10B is a flow diagram of the process of setting up and copying a block.

Fig. 11A shows a menu for recalling a snapshot.

Fig. 11B shows a menu for storing a snapshot.

### Description of the Preferred Embodiments

#### General Description

Fig. 1 is a perspective view of a mixing system 11 according to a preferred embodiment of the invention, called the Crescendo System by the inventors, wherein the essential functions are strictly separated into a control mainframe 13 and an audio mainframe 15. In this embodiment, and in other embodiments of the invention, control mainframe 13 comprises control hardware and computer components. There are no

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audio signals fed to, processed by, or routed from the control mainframe, other than talkback and headphone systems required for control communication. All audio signals to be processed and mixed go to, are processed by, and are output from audio mainframe 15. Processing and routing in the audio mainframe is done by digitally controlled analog devices. This strict separation allows audio to be located away from the control functions, in the preferred embodiment as far as 25 meters away, so the audio mainframe may be located even in a separate room from the control mainframe.

Communication between control mainframe 13 and the audio mainframe is digital in nature, and via cables carried in signal pathway 17. Many other layouts for connection between the control mainframe and the audio mainframe are suitable, such as under the floor, overhead, and so forth.

In the embodiment shown in Fig. 1 control mainframe 13 comprises a control console 19 carried on a support frame 21; computer elements not shown in Fig. 1; a computer monitor 23 which is a part of an 80386-based PC 59; and a "mouse" computer input device 25 as known in the art. Console 19 has eight removable I/O control modules 27, 29, 31, 33, 35, 37, 39, and 41 in the preferred embodiment. There can be fewer or more in other embodiments. The removable modules are called pods. Each pod except pod 35 comprises 4 I/O control channels, analogous to I/O channels in a conventional console. Pod 35 is a Master Module comprising a Master Section and a Command Section. Many other pod configurations on the console control surface are possible. For example, a user can place the Master Module in any one of the pod bays. The master section comprises monitor controls, master auxiliary sends, two stereo output faders, and other master control input devices described below relative to Fig. 5A through Fig.

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5D. The command section comprises interface devices for configuration, routing, and automation, such as a data entry wheel and an alpha-numeric display.

#### System Hardware Organization and Communication

Fig. 2 is a block diagram showing the physical and signal architecture of the Crescendo system in the preferred embodiment. Each of the several pods in console 19 is connected via a separate control cable assembly to a group of four electronic modules in the audio mainframe. Each of the electronic modules in the audio mainframe is an assembly of digitally controllable components for managing audio signals, with the components typically implemented as plug-in printed circuit boards. Also, each of the four electronic modules in each group is associated with a single channel in the connected digital control module in the console. For example, pod 27 is connected to the audio mainframe via cable assembly 43, and at the audio mainframe there are four electronic modules 45, 47, 49, and 51, each associated with 1 control channel in pod 27. Portion 53 of the audio mainframe has 7 groups of four electronics modules in the preferred embodiment, each group coupled by a separate cable to a pod module at the console. There are more or fewer in other embodiments that have more or fewer pods in the console.

The use of separate cables for each of the pod modules of the console provides redundancy for the communication link. In the event of damage to a single cable carrying all of the digital signals between the console and the audio mainframe, the entire console function would be interrupted. In the case of separate cables, only the modules connected to a damaged cable would be affected, and the balance of functions would

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still be useable.

The communication link between the pods and the audio mainframe is based on a high-speed serial protocol operating at about 2 megabits per second, to assure immediate response of audio control circuits in the mainframe to changes commanded at the console. Also in the preferred embodiment all of the cable connections carrying digital code to and from the audio mainframe are optically isolated at the mainframe to provide complete electrical separation of the control functions from the audio (analog) sections. Master control pod 35 is similarly coupled by a high speed serial link to master section 57 in the audio mainframe.

A patch bay 55 separate from the audio mainframe provides plug connections for all inputs and outputs, and provides an assignment facility for all audio signals. An engineer plugs mike and line inputs into any channel at the patch bay, and takes off outputs from any channel, as well as mono and stereo output buses and other outputs from the mainframe. The patch bay is connected to the audio mainframe via multipair audio cables, with both ends terminating in Elco connectors. Every physical input and output terminates in a plug at the patch bay.

In the preferred embodiment IBM-compatible 80386-based PC 59, including monitor 23 and floppy-disk drive 24, is coupled to the master control pod via an RS-232 communication link 61 operating at about 38.4 Kbaud, and provides additional programming capability through unique software called the MixView graphic interface. The Crescendo system is fully functional without the PC interface, but the computer adds additional control dimensions and non-volatile storage capacity.

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An I/O Channel

A conventional mixer I/O channel typically has 1 mike input, 1 line/tape input, 1 long throw mono fader, 1 short throw mono fader, 1 EQ section, 4 to 6 mono aux sends, 4 to 8 aux buses, 1 mono direct output, 1 effects loop, and group output trim control. These components are typical, and vary somewhat from manufacturer to manufacturer. An I/O channel for the mixer in the preferred embodiment has 2 mike inputs, 4 line/tape inputs, 2 long throw stereo or mono faders, 2 EQ sections, 4 mono/2 stereo aux sends, 8 aux buses, 1 mono/stereo direct output, 3 effects loops using line inputs, and group/submix output trim. Fig. 3A is a detailed layout of input devices and meters for a single I/O channel 63 in the preferred embodiment, with specific groups of elements magnified to show additional detail.

Beginning at the top of the single channel, there are two software-driven bargraph meters 65 and 67. These are assignable to display amplitudes of virtually any signal or signal mix including channel inputs, channel outputs, multitrack buses, or automated fader movements. The dynamic range of the meters is adjustable for precise calibration or headroom monitoring while showing either peak or VU characteristics. Fig. 3B shows the meters and associated features in more detail. The meters are assignable through the command section, and are driven by digital signals delivered to the channel from the audio mainframe via the same high-speed serial link that delivers input settings to the audio mainframe.

Block 69 is a display to indicate the assignment for each of three Insert Sends called Out 1, Out 2, and Out 3. These are prefader, post EQ outputs. The channel sources are assignable at each insert send, immediately after the EQ.

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These outputs are typically used as insert points for sending a pre-fader signal to a dynamic controller, such as a compressor/limiter, then back to the channels line inputs. Button 71 is a block attention key used in the assignment process for the Insert Sends.

The meters are outputs and do not include variable input devices. Each control block of input devices in an input channel is associated with a specific signal processing device in the audio mainframe, and each control block has a block attention key as well, to enable the block for assignment at the master control section described below.

Each I/O channel has control blocks 73 and 75 for two ultra-low-noise universal input amplifiers in the audio mainframe. Block 73 is shown in additional detail in Fig. 3C. The amps can be assigned to mike or line level sources. The level controls can be software linked if desired to adjust the gain of a stereo source. Other software settable features include phantom power, phase reverse, and a 100 Hz hi-pass filter. A pad function is automatic. Four line inputs are also included to serve as effect returns or insert points. Knob 77 (Fig. 3C) is for setting the gain. Key 79 is the block attention key to enable the amplifier control block for set-up at the Command Module, which is described below. Display 81 is for displaying configuration characteristics: phantom power, pad, phase reverse, and the use of the 100 Hz hi-pass filter. Hidden-til-lit display 83 is for indicating the routing assignment of the amplifier. In this case, the amp is assigned to microphone 1 (M1) alone.

There are four auxiliary sends associated with each I/O channel, with controls arranged in two control blocks. Block 85 is for sends A and B, and block 87 for sends C and D. Block 85 is shown in additional detail in Fig. 3D. The sends



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are assignable to 8 auxiliary buses. These sends are for cue mixing or effects processing. Key 95 is a block attention key for enabling the send block for configuration at the Command Section. Knobs 89 and 97 are gain controls. Display 91 shows input selections and display 93 shows output assignments.

There are two four-band programmable parametric equalizers associated with each I/O channel. The equalizers can be linked together for stereo or used separately with two mono sources. With a PC monitor coupled to the command section and the MixView software active, graphic display of EQ response curves make adjustment simple and intuitive. Favorite settings can be stored and recalled for re-use through the command section. Keys 86 and 88 at the lower fader control block are block attention keys for the EQs, and are labeled EQ1 and EQ2 respectively.

Each I/O channel has two faders 99 and 101 that are alike except for assignment flexibility. Fader 99 is shown in additional detail in Fig. 3E. Fader setting lever 103 can be set at any point along 100 mm track 105, and the track is annotated with a linear 0 through 10 scale. Block 107 indicates source assigned and block 109 indicates output assignment. Button 111 is the block attention key for the fader.

Upper fader 99 can operate in either a mono or a stereo mode and its output can be assigned to either of two stereo or any of 24 tape buses, or to two separate direct outputs. Its source or its output can be soloed using PFL (pre fader listen) key 113, or AFL (after fader listen) key 115. On either fader, ON key 117 is used to add (or remove) the fader's output from its assigned mix buses.

Lower fader 101 can be used to create a monitor mix during tracking or used as a full-function fader during mixdown. The output of the lower fader is not assignable to

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the tape buses. Any combination of faders can be software linked, allowing an infinite number of grouping possibilities.

#### Console Modularity

Each pod module 27, 29, 31, 33, 37, 39, and 41 (Fig. 2) comprises four I/O channels of the architecture shown by Figs. 3A, B, C, D, and E. Fig. 4 shows a pod module 27 removed from pod bay 119 in console 19. A pod module is removed by first lifting top rear panel 121 (Fig. 2), which exposes the rear of the pod modules. Every module has a handle for lifting it from the pod bay, which isn't shown in Fig. 4. One simply grasps the handle and lifts upward. Electrical connection is via a connector with a portion 123 attached to the bay, and a mating portion 125 mounted under the pod module. The pod module fits in the bay closely enough that the connector mates when the module is seated in the bay.

Connector portion 123 is coupled to a printed circuit board (not shown) which provides electrical bus to another connector to mate to one end of the cable group that runs to the audio mainframe for that particular pod module.

The use of a separate cable for each module to the audio mainframe and the ease with which a module may be removed and replaced provides maximum redundancy and flexibility. Loss of a single cable disables only a single I/O module. Moreover, removability provides maintenance and troubleshooting advantages. Keeping a single spare module allows a user to switch out a malfunctioning module, keep the console operating, and perform tests and repair off line.

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### The Master Module

Fig. 5A illustrates Master Module 35. The Master Module comprises digital bar-graph meters, (not shown) Macro Section 126, Master Section 127, and Command Section 129. Fig. 5B shows the Macro Section 126 in more detail. The Macro Section has 24 Macro keys like key 128 for accomplishing procedures otherwise requiring several keystrokes in a single keystroke. The macro keys are configured by a procedure described below.

Fig. 5C shows Master Section 127 in more detail, which includes several input blocks for signal control devices in the audio mainframe that have more general application than the devices associated with an I/O channel. There are four auxiliary bus master control blocks 131, 133, 135, and 137. Each block controls a pair of auxiliary buses that can be configured as mono individual buses or stereo pairs. The auxiliary buses are typically used for cue mixes or as group sends to mono or stereo signal processors. Each individual aux bus has a send level control pot and an on/off key with an indicator. Each pair has a block attention key, such as key 139 for pair 131.

There are two master faders 147 and 149 that control two main stereo mix buses in the audio mainframe.

The Master Section also has three monitor outputs 151, 153, and 155 that can be sourced from any of the mixing buses or from two external stereo inputs. A typical configuration consists of one control-room monitor and two studio cues. Monitor set block 141 is for configuring each of the monitors. To configure a monitor, the user presses the Set key at a monitor control block, then presses the appropriate keys in block 141. The setting keys can sum as well as select, so a

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single monitor output can be across several buses at once.

Control block 157 is for controlling a kill/solo bus, which can be directed to any or all of the monitor outputs. The activation of any pre-fader listen (PFL) or after-fader listen (AFL) on an I/O channel replaces the program on the monitor output with the channels chosen to solo. The monitor output returns to normal after the PFL or AFL is deactivated.

Control block 159 is for a headphone amplifier which can be selected to monitor any or all monitor outputs. Talkback control block 161 has a built-in talkback mike 163, which is switchable to an external mike (not shown), and a test tone oscillator that can be assigned to any of the mixer buses or to an output jack (patch) on the audio mainframe or the patchbay. There is a destination display, a block attention key, and an on/off toggle key for the talkback circuit.

Fig. 5D shows Command Section 129, which is a control interface for a user to make assignments and setup of the Crescendo's many input and output functions. The command section includes a multi-segment LED monitor 165 for presenting information back to a user and for associating with a set of four soft keys 167. There are dedicated keys for clear (169) and escape (171). There is a ten-key input pad 175 for numerical input and a data entry wheel 177 for indexing through pre-programmed variables to display for input. There is also a set of source attention keys (179) and a set of Assign keys (181).

Just above the data entry wheel 177 there are keys 173, 166, 172, and 170, which are associated with Automation functions. Keys 174, 176, and 178 below the data entry wheel are also associated with automation functions. Above monitor 165 a backlit display 162 indicates the power status of the Audio Mainframe, and another backlit display 164 indicates the

-17-

on/off status of the Automation function.

The Master Module is cabled to the audio mainframe in the same way as the channel modules, with a high-speed serial communication cable assembly. The Master Module is removable and replaceable in the same manner as the other pod modules. There is (not shown) a serial connector for connecting the Master Module to PC 59 (Fig. 1). The communication mode with the PC is RS-232 in the preferred embodiment. The Crescendo system is fully operational without the PC and display monitor 23, but the PC sub-system adds extra control dimensions for the system in alternative embodiments.

Fig. 6 is a block diagram of elements of the Crescendo control system. Each I/O pod module, comprising four channels, has an electronics module including a Zilog Z80 microprocessor, Ram memory that can be expanded, and a small ROM. The electronics modules for each pod module are modules 183, 185, 187, 189, 191, 193, and 195; associated with pod modules 27, 29, 31, 33, 37, 39, and 41 respectively. Each electronics module also has RAM and ROM memory. Electronics module 197 is in the Master section of the Master Module, and also includes a Z-80 microprocessor, RAM, and ROM. Electronics module 199 serves the Command Section, and also includes a Z-80 microprocessor, RAM, and ROM. There is an additional Bulletin-Board RAM 201 in the Master Module, accessible to all the microprocessors, for usually temporary storage of commands, configurations, and other data. The microprocessors communicate on internal 8-bit data bus 203 and 16-bit address bus 205. There are also power and control signal connections between the microprocessors, the memories, and other elements, as known in the art, represented by lines 207.

Fig. 9 shows a typical arrangement for an input device

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243, such as a trim pot or a fader at an input block. The variable level input devices are generically variable resistors with a DC input supply V1 of typically about 2.5 volts. The reference voltage V2 is conveyed to the appropriate electronics module (see Fig. 6) where it is processed through an analog to digital converter 245, and the digital data representing the setting of the input device is stored at an appropriate assigned addresses in RAM 295 via a bus structure 297 internal to the pod containing the channel supporting the input device. Input devices that are keys (buttons) are represented by contact closure 301 providing a momentary signal at the DC voltage which is converted to a digital equivalent by the analog to digital function and stored at an appropriate assigned address in RAM. It is the storage of data representing input settings that provides maximum flexibility and software-based control for the mix controller.

Storage, retrieval, and output of data is controlled by microprocessor 299 in the representative schematic of Fig. 9. Each I/O pod has such a microprocessor and RAM. The microprocessor also controls transmission of digital data, via a communications interface 303 and a cable connection 305 for each pod, to the audio mainframe, where an optical isolator 307 and another communications interface 309 provide for putting the data on a control bus 311 where individual digitally controlled, addressable, analog audio signal processors represented by processor 313 access the data to control the audio signals to be processed and mixed.

There are several different kinds of digitally controlled analog audio processors represented by processor 313. Some are essentially "switches" with more than one input and output that can be controlled to sum two or more signals. These are

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used in routing assignments for inputs and output buses. Others are such as programmable parametric equalizers, amplifiers, and faders, that alter the audio signals routed to them according to the digital commands they receive.

Returning now to Fig. 6, electronics module 197 serving the Master Section outputs data on a bus 217 to connector 219 which connects to cable 221 to the audio mainframe. Electronics module 199 associated with the Command Section outputs data on a bus 223 to a connector 225 connected to RS-232 link 227 to PC 59 shown in Fig. 1.

### Menu System

System control is accomplished by the user at the various control blocks, at the Command Section of the Master Module and through control screens on monitor 23. Input devices at the command section were described briefly above.

In the Crescendo system, virtually every input can be assigned to virtually every output, and there is complete flexibility in mixing signals. There are, as described above, 2 mike and 4 line inputs (sources) for every I/O channel. The total number of inputs is flexible, as there is flexibility in the number of I/O modules, each with four I/O channels, that may be provided with a system. In the embodiment described herein there are seven modules, hence twenty-eight I/O channels, hence 56 mike inputs and 112 line inputs, routable through the fifty-six faders, with two faders per I/O channel. Any fader can be mono or stereo, or receive up to four line and two microphone inputs simultaneously.

There are two user interfaces for control set-up and signal routing, the PC screen and the Command Section of the Master Module. The input and readout devices referred to in

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the present description of command procedures at the command Section are relative to Fig. 5D, as described above.

User input at the Command Section is via a hierarchical menu system displayed on monitor 165. The routines for the display are stored in memory, and retrieved and displayed in response to user signals. In the preferred embodiment the essential routines are in ROM memory associated with microprocessor 223 in the Command Section. When the Crescendo system is first powered up, essential routines are copied from ROM to RAM associated with each of the microprocessors in the control system.

Fig. 7A shows the four level menu system in the preferred embodiment. The top level (Level 1) menu has four selections: Setup, Snap, Auto, and System, shown within a dotted enclosure 239. This top-level menu is shown displayed on monitor 165 (Fig. 5D), and each selection is aligned with one of the soft keys 167. By pressing a soft key directly below a menu selection, the user accesses another menu, if a lower level menu is available. Otherwise control procedures are enabled through the menu displayed.

For example, following the hierarchy shown in Fig. 7A, a user can press the soft key below Setup in the top level menu, and monitor 165 will display the second level menu with Sess (for session), Master, and Console as selections. By pressing the softkey under Console in the second level menu, the user accesses a new menu with Custom, Show, Meter, and Mute as selections.

At the end of each downward path there is a control function. For example, one may select Sys (for System) from the top level menu, then Hdwr (for Hardware), then Pwr (for Power), and arrive at a menu with two selections, Rstrt (for Restart) and Sdown (for Shutdown). In this case, pressing the



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softkey under Rstrt causes the system power to disengage, then restart in a programmed manner to bring up all powered equipment in an orderly and safe sequence according to system defaults, and properly initialize all powered equipment. Similarly, the key under Sdown will cause the system to shut down all power in an orderly fashion without danger of damage to components or loss of important settings or data. In some other cases the final menu function will prompt the user for some input at the ten-key numerical input pad.

#### Console Initiated Menu Control

Unique to the present invention is a setup procedure initiated from the control blocks and used in combination with the menu system to set up routing of audio through the signal processing devices in the Audio Mainframe, relative to the control blocks on the control console face, and in some cases other functions. This procedure begins with a block attention key as described above. Fig. 7B shows a menu system initiated by block attention keys at control blocks in I/O channels on the Crescendo console. The "nn" preceding each designation at the top (1) level represents a Channel number on the console face.

In Fig. 7B there are top level entry points for each attention key in a channel strip. As an example, UF is for upper fader, and LF is for lower fader. A simple example will serve to illustrate the utility and value of the procedure.

If the user presses the block attention key for the upper fader in Channel 3, which is key 111 in Fig. 3E, the system displays in response the menu shown in Fig. 8A. 3UF on the display refers to the upper fader (UF) for I/O channel 3. Channel 3 is used arbitrarily, and the number will reflect

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which block attention key is pressed. Arrow symbol 229 denotes the attention function is active.

The rest of display reads MODE, SRC (for source), and ASGN (for assign). This menu is indicated in the menu hierarchy shown by Fig. 7B. Each of these labels represents a function, and a particular function may be accessed by pressing the softkey directly below the label. For example, to direct inputs (sources) to channel 3 upper fader, one would press the SRC key. Sources are then selected by pressing buttons in Source Input Block 179. Any combination or all of the two mike sources and four line sources may be selected. In this example sources M1, M2 and L3 are selected, and the selections are then displayed on LCD display 165 as shown in Fig. 8B. The operator enters the selections and completes the process by pressing decimal button 231 (Fig. 5), which enters the selection and completes the function.

When the input selections are made as described above, the selections are displayed on the panel face by backlighting the appropriate display numbers in source block 107 in the control block for the upper fader in channel 3 (Fig. 3E). The designations M1, M2, and L3 "light up" in block 107 at the location of the upper fader on the console. Input assignments for all other components with controls available on the I/O console are made in substantially the same manner, by pressing the appropriate block attention key, selecting SRC in the LCD display, and entering the input or inputs from block 179 to be associated with the selected component.

Output routing is done in a manner similar to the procedure for input routing. One calls attention to a component as before, by pressing a block attention key, then presses the softkey labeled ASGN. Output associations are then selected at ASGN block 181 (Fig. 5D). Button 233, labeled

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A/MT, denotes auxiliary buses, of which eight are available, or multi-track output, which may vary in number depending on the multi-track tape deck employed. So, to route a component output to one of the eight auxiliary buses, one presses the A/MT key, then a number in the numerical input block 175. Button 235 denotes association to a direct (dir) output bus, of which there are two, usually switched on and off together. Again, the number is entered at numerical key pad 175.

ST key 237 denotes a stereo bus, of which there are two, and the number one or two is entered as before at the numerical keypad followed by the enter key. A user can assign any component output to any one of the buses, or to any combination. After selecting output assignments the assignments are highlighted in the display at No. 3 upper fader control block.

There are functions other than routing of audio signals that can be set via block attention initiated menus. A good example is the setting of fader modes. When the user presses a block attention key for a fader, such as number 3 upper fader, the menu reflects the initiation as shown in Fig. 8A, which was used to describe routing procedures. To set a mode, which determines how the fader controls the input signal, the user presses the Mode softkey, and the system displays any of twelve programmed fader modes. The modes include Disabled, mono modes, and stereo modes. As an example, one of the modes is Mono Pan Center, in which all inputs to the fader are summed to mono, and the signal is automatically panned center and is not adjustable. A worker with skill in the art will recognize that there are a broad variety of useful modes that may be programmed and assigned. To enter a mode after the mode is displayed, the user presses the soft key under the mode name in the display.

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Auxiliary sends are programmable with modes in the same fashion as faders, but there are several more modes for the sends, these being post fader modes.

The block attention procedure provides the user with a direct and physical location fix when assigning inputs, outputs, and modes, and displaying modes and routings at the control block after the associations are set at the Command Section provides an always active association at the block, so it is seldom necessary to "call up" a display to recheck.

Fig. 7C shows the hierarchical menu tree for the Master Section, providing block attention initiated configuration procedure from the Master Section in the same way as for the channel routing procedure described above.

#### Block Copy

Another unique ability provided by the invention is called Block Copy. By Block Copy one can configure one control block, routing sources to and assigning outputs from, and then Block Copy the configuration to any other control block on the console (capable of having the same routing assignments) by a simple and direct procedure. As an example, if one makes the assignments to channel number 3 upper fader as in Fig. 8A, the system displays the assignments as shown in Fig. 8B. Then the user can press soft key 241 enabling the Block Copy function. Pressing the block attention key at any other blocks capable of accepting the assignments of channel number 3 upper fader then copies the routing configuration to the block where the attention key is pressed.

With Block Copy a user can set up routing for the upper fader of channel number 1, for example, and then copy that routing across all the channels simply by pressing the block

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attention keys for the upper faders one after another.

The Block Copy mechanics are shown by Fig. 10A. Every routing for a block is stored in a particular addressed space in RAM. For example, routing for number 3 upper fader may be stored in memory space 247 beginning at address A3, and routing for number 11 upper fader in space 249 beginning at address A11. A simple routing may be stored in a single address word, and a more complicated routing may take more than one address word.

Fig. 10B shows the routing and Block Copy procedure represented by a stepwise flow diagram for setting up a routing for a block and copying the routing to other blocks. The flow diagram is a specific example of the procedure as provided for setting up routing for any block and copying from any one block to another.

At step 253 the user presses the block attention key for a block, and the system responds at step 255 by displaying the routing menu for the block. At step 257 the user presses the softkey under SRC (for Source). At step 259 the user selects sources (inputs) from the Source Block in the Command Section and enters the selections by the decimal Enter key. At step 261 the system displays the selections both on the monitor and at the particular block. At step 263 the user returns to the routing menu and presses the softkey for ASGN. At step 265 the user selects output assignments and enters the selections. At step 267 the user returns to the routing menu and presses the softkey under the block identification in the menu. For the menu shown in Fig. 8A, this is key 275. In response, at step 269, the system activates the Block Copy function. At step 271 the user selects blocks to copy to, and presses the block attention key for each. At step 273 the system copies the routing to each block where the attention key is pressed.

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The copies are made and routings displayed at the block as each block attention key is pressed. The system makes a copy of the data in the memory section for the original block (being copied) and places a copy in the memory section for each block copied to, overwriting the data in the block copied to. This process is represented by arrow 251 in Fig. 10A. At step 274 the user presses the softkey under the block ID in the menu to signal the system to revert to the Block Attention mode. If the user does not initiate the reversion, the system automatically reverts in ten seconds.

### Snapshots

The Snap selection from the top level menu enables a Snapshot function unique to the present invention. With Snapshot, a user can store all the immediate settings of the console for later recall. Snapshot provides a way to store favorite configurations to be used in similar situations, or even to store on a floppy disk and use the data to set up another Crescendo system at another location. In the preferred embodiment up to 99 user-definable Snapshots are stored at preselected memory spaces in RAM 201.

To access the Snapshot function the user presses the softkey under Snap from the top level menu shown in the Command Section display in Fig. 5D. The system responds by displaying the menu shown in Fig. 11A. The designations 279 at the left of the menu including "SS" simply indicate that this is the Snapshot menu. Designation 281 "RCL" indicates the Snapshot function is in the Recall mode, allowing a user to select a stored configuration and copy it to the console. The Recall mode is the default when the Snapshot function is initiated, to avoid storing unwanted configurations, which

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might overwrite other information in memory.

To put the system in the Store mode the user must press softkey 277 to toggle the display from that shown in Fig. 11A to the display shown in Fig. 11B. The system always reverts to the Recall mode after a Snapshot is stored. In Fig. 11B designation 281 says "STO" for Store, and indicates the Snapshot function is in the Store mode.

To store a Snapshot, that is, data indicating all of the immediate settings and routing assignments of the console, which is the entire console configuration, the user, with Snapshot in the Store mode, selects a Snapshot number (283) from 1 to 99. The numbers can be changed by entry on the numeric keypad at the Command Section, or by rotating data entry wheel 177. When the desired number is displayed, the user presses softkey 285 under the number display, and the system stores the configuration in the memory space reserved for that number. If another configuration is already stored at that memory space, the old data is erased and the new inserted.

To recall a stored configuration it is helpful to be able to browse through stored data. To do this, with Snapshot in the RCL mode, the user can scroll through the stored snapshots, recalling them one by one. Pressing the "+" key in the ASGN block at the command section scrolls forward, and pressing the "-" key scrolls backward. The Snapshot numbers are displayed in the menu display and the configuration is shown by lighting the LEDs at all of the blocks on the console.

Snapshots may also be stored to the floppy disk associated with the attached PC, and transferred between the floppy disk and RAM 201, using simple command techniques initiated at the PC or at the Command Section.

When a Snapshot is recalled, configuring the Crescendo

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console to a stored configuration, some of the physical settings of input devices in the blocks may not be the same as the values being communicated to the mainframe by the software in behalf of that particular block. For example, a physical fader position might well be completely off (in the lowermost position) while the software is communicating data indicating a much higher setting.

At a fader, when the physical position is not the same as the communicated value, there is a group of LED indicators 287, 288, and 289 (Fig. 3E) that indicate the situation. If the green LED 288 is lit, the physical position and the "software" position are the same, although the software position and the physical position are not linked. If the green LED is not lit, and it would be required to move the fader "up" to align it to the software position, "up" arrow 287 will be lit. If it is necessary to move the fader "down" to align, "down" arrow 289 will be lit. A user can simply move the fader in the right direction until the green LED is lit, indicating alignment and agreement. If none of the LEDs is lit, the software and physical positions are in agreement, and the two are linked, meaning if the user moves the physical position the software position will follow. To link the positions when they are not linked, it is necessary to press the block attention key.

For a rotary knob, such as knob 291 in Fig. 3E which activates a rotary potentiometer (pot), there is an LED indicator 293. If the LED is red, the physical setting and the software setting do not agree. If the LED is green the settings agree. There is no direction indication.

In addition to user-definable Snapshots and default Snapshots a user can access, there is an automatic backup function based on Snapshots. Through this facility the system creates a backup of the entire console configuration with a



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user-definable frequency, ranging from once per minute to once every 99 minutes. Every time the system stores a backup Snapshot, it replaces the previous backup snapshot. This way, in the event of a power failure or some other disaster that results in "losing the board", the user can recall the backup and restore the configuration as it was at a recent moment. To set up the backup parameters, such as the time frequency, the user accesses the Backup menu below the Sys selection in the top level menu.

### Automation

Block Copy and Snapshot are static functions for copying data as it exists at an instant in time. The Crescendo also includes automatic functionality which is dynamic in nature. You can record dynamic sequences comprising changes in routing and changes in settings of signal processing equipment, and synchronize the recorded sequences to incoming SMPTE time code. SMPTE stands for the Society of Motion Picture and Television Engineers. In playback mode, the Crescendo will make the recorded changes automatically at specific times.

The physical controls, such as fader positions, do not change during playback, but the software changes the actual settings, which includes the data sent to the audio mainframe. The indications at the specific blocks as to whether the physical settings differ or are the same as the software driven settings, is the same as described above for the Snapshot function.

The Automation function is accessed by pressing the softkey under Auto in the top level menu. The top level menu has those selections in box 239 of Fig. 7A. The lower level

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selections under the Auto selection can be seen in the diagram as ON/OFF, Start, Punch, Offset, Rate, Locate, and Build Mix.

### Macro Keys

There are 24 Macro keys in a block 126 at the top of the Master Section, with four attention keys above labeled Master, Console, Meter, and Macro. The four attention keys are for "calling attention" to blocks or functions not accessed by specific block attention keys on the console. Macro calls attention to Macro block 126 in the Master Module, and enables set up of Macro sequences. To record a sequence, a user presses the Macro attention key, then a specific macro key 1 through 24. Then the sequence of operations, such as key strokes, that the user makes until the Macro attention key is pressed again is recorded in a memory space reserved for that Macro key number, up to the memory capacity available for that Macro key.

To recall a macro sequence, the user only need press the Macro key during any other operation, and the recorded Macro sequence is entered.

It will be apparent to one with skill in the art that there are a number of equivalent ways that the system of the invention might be implemented without departing from the spirit and scope of the invention. There are, for example, several different microprocessors that might be used rather than the Z80 microprocessors in the preferred embodiment. Similarly, there are many alternative ways that input devices might be arranged on the control surface, and channels might be organized in removable pods in groups other than groups of four channels. Also, There are many commercially available switches, slide faders, meters, and so forth, that fulfill the

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requirements for the invention. There are similarly many other changes and alterations that might be made without departing from the spirit and scope of the invention.

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What is claimed is:

1. A mix controller for processing and mixing audio signals comprising:

audio mainframe means for receiving, processing and mixing, and outputting said audio signals through digitally controllable analog audio control devices contained in said audio mainframe means;

console means for inputting analog electric control signals and for displaying control status and signal characteristics, including signal routing;

microprocessor-based control means coupled to said console means for receiving said analog electric control signals, converting said analog electric control signals to digital data, storing and retrieving said digital data, and for controlling digital data transfer between said console means and said audio mainframe means; and

data communication means connecting said audio mainframe means and said console means for carrying said digital data between said audio mainframe means and said console means;

said digitally controllable analog audio control devices responsive to digital data converted from said analog electric control signals by said microprocessor-based control means.

2. A mix controller as in claim 1 wherein said console means comprises manually settable analog electrical input devices for inputting said analog electric control signals, and lightable displays for displaying said control status and signal characteristics, including signal routing, and said manually

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settable analog electrical input devices and lightable displays are grouped in control blocks on a top surface of said console means, each control block corresponding to one of said digitally controllable analog audio control devices contained in said audio mainframe means.

3. A mix controller as in claim 2 wherein said microprocessor-based control means comprises plural microprocessors and plural RAM memory units, and said control blocks are arranged in individual input/output channel arrays on said top surface of said console means, wherein at least two of said input/output channel arrays form a pod module comprising said channel arrays of said control blocks, at least one of said microprocessors, and at least one of said RAM memory units, said pod module being connected to said console means by a first digital data link with a first separable connector such that said pod module is removable from said console means.

4. A mix controller as in claim 3 wherein said input/output channel arrays comprise at least one digitally controlled bar graph meter for displaying data.

5. A mix controller as in claim 3 wherein said data communication means comprises a plurality of digital communication cables, and said control blocks arrayed on said pod module communicate with an audio electronic module at said audio mainframe, said audio electronic module having one of said digitally controllable analog audio control devices for each of said control blocks, and said audio electronic module and said pod module are connected by and communicate over one of said plurality of digital communication cables.

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6. A mix controller as in claim 3 wherein said console means further comprises a master pod module, said master pod module comprising a master section with individual ones of said control blocks for supplying said analog electric control signals for digitally controllable analog audio control devices not controlled by control blocks at input-output channel arrays, and a command section having input devices for providing control commands to said system and a display for displaying menus, commands, and control data, said master section having at least one of said microprocessors and at least one of said RAM memory units, said command section also having at least one of said microprocessors and at least one of said RAM units, said master pod module connected to said console means by a second digital data link with a second separable connector, such that said master pod module is removable from said console means.

7. A mix controller as in claim 6 wherein individual ones of said control blocks comprise a block attention key for enabling the block for set up of signal routing and prestored control modes by commands input at said command section.

8. A method for controlling a digitally controllable analog audio control device in a mix controller having control blocks of input devices and displays on a console face, and a microprocessor-based control system comprising user-selectable functions from a menu, said method comprising the steps of:

- calling attention to a control block by pressing a block attention key at the control block;

- selecting control functions from said menu;

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entering data to control routing of audio signals to and from said audio control device and control modes for said audio control device; and

displaying signal routing and control mode settings on said displays at said control block.

9. The method of claim 8 comprising copying of control mode and routing settings from one control block to another by:

selecting a copy function from said menu; and

pressing said block attention key at each control block where it is desired to copy the control mode settings and routing.

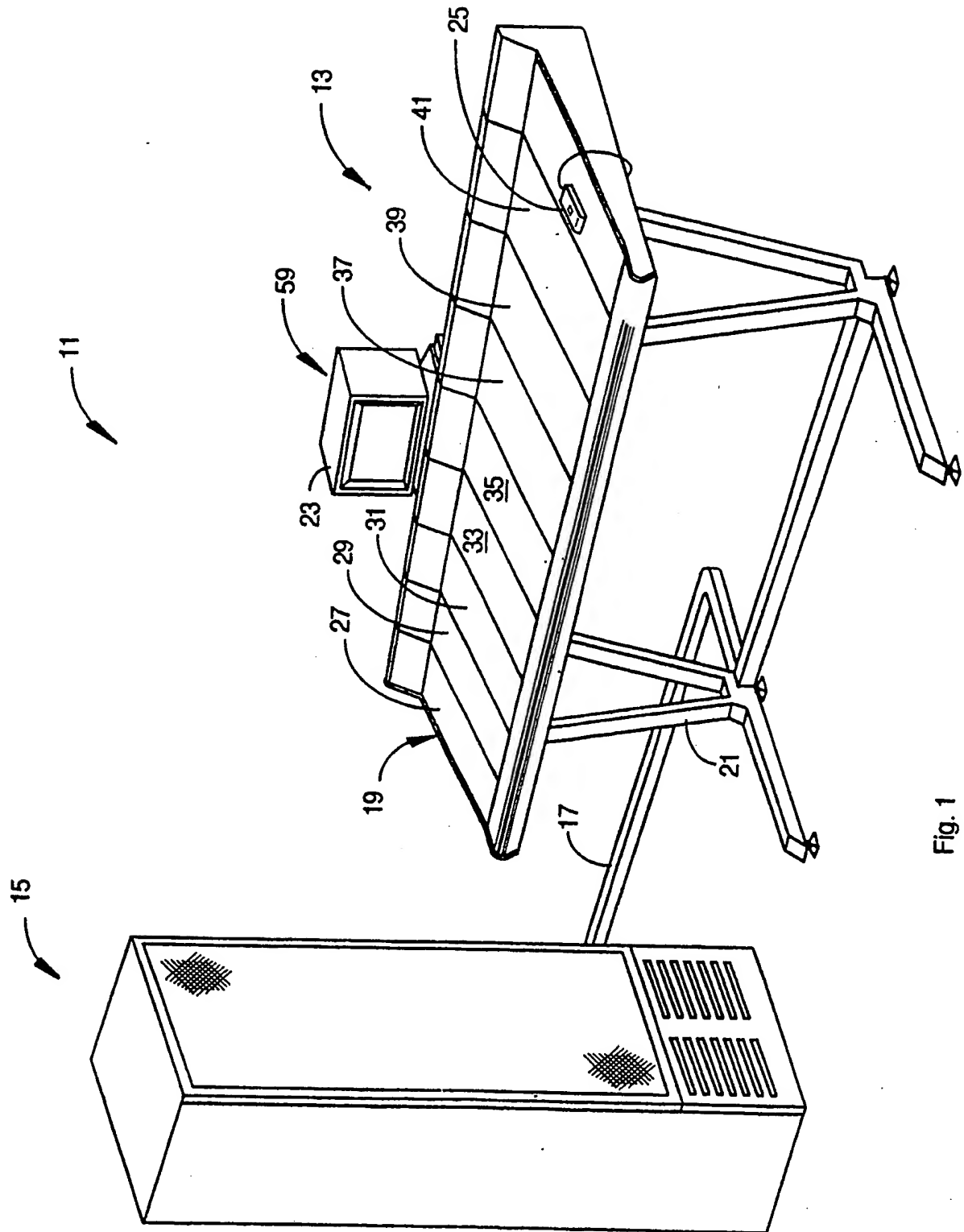
10. A method for restoring configurations of a mix controller control console, said console comprising a microprocessor-based control system including user-selectable functions, said method comprising:

storing all assignments and configurations for said control console in a snapshot digital data array in a memory unit by selecting a snapshot function;

changing one or more settings on said control console; and

recalling said snapshot by selecting a recall function.

11. The method of claim 10 wherein said snapshot is produced automatically at intervals of time selectable by a user, and a user selectable number of snapshots are stored, new snapshots replacing the oldest snapshots.





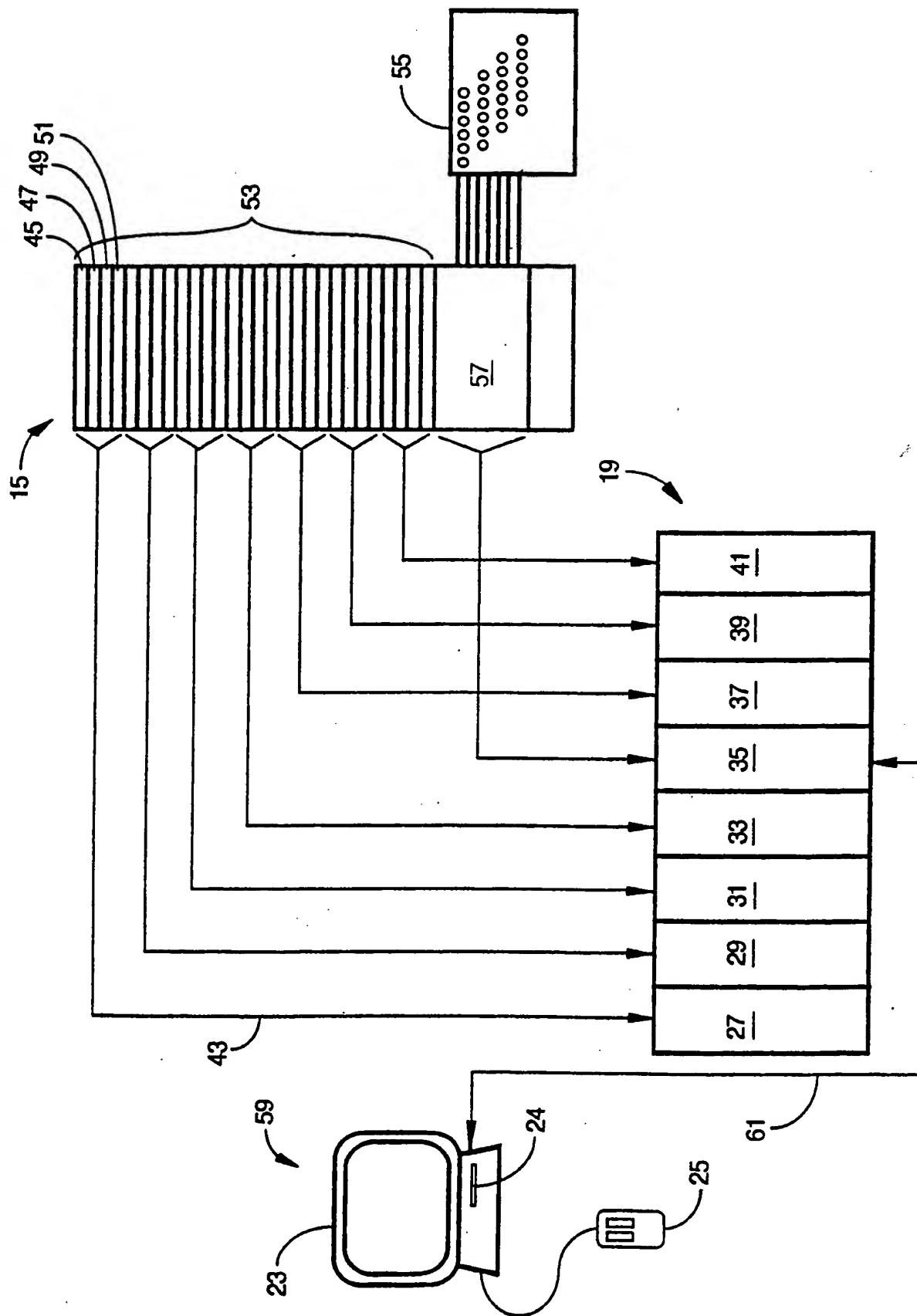


Fig. 2

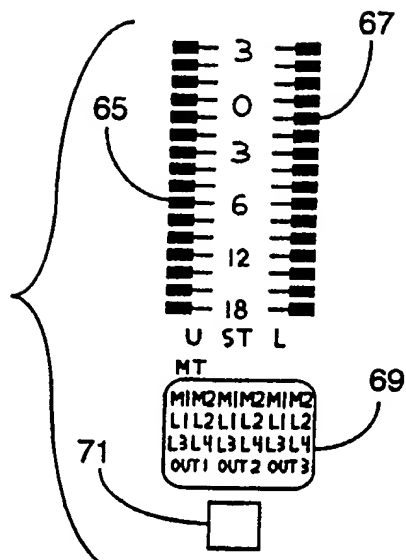


Fig. 3B

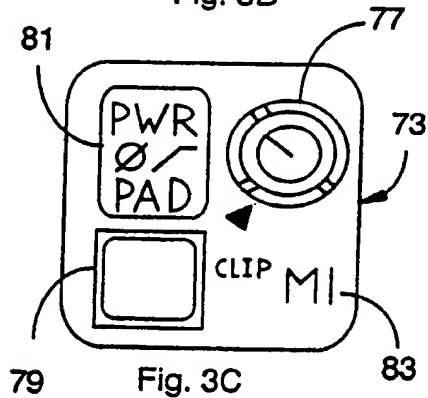


Fig. 3C

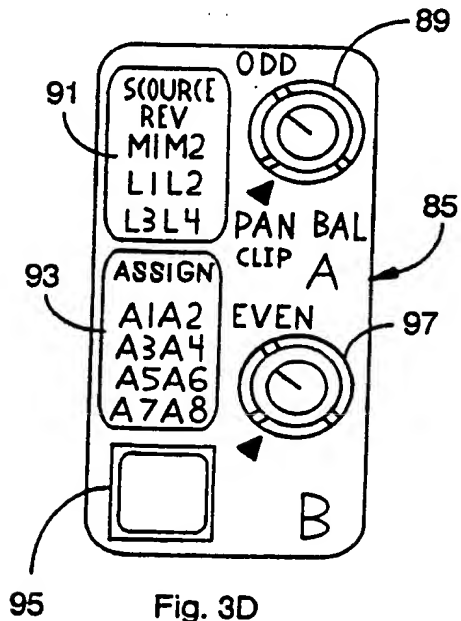


Fig. 3D

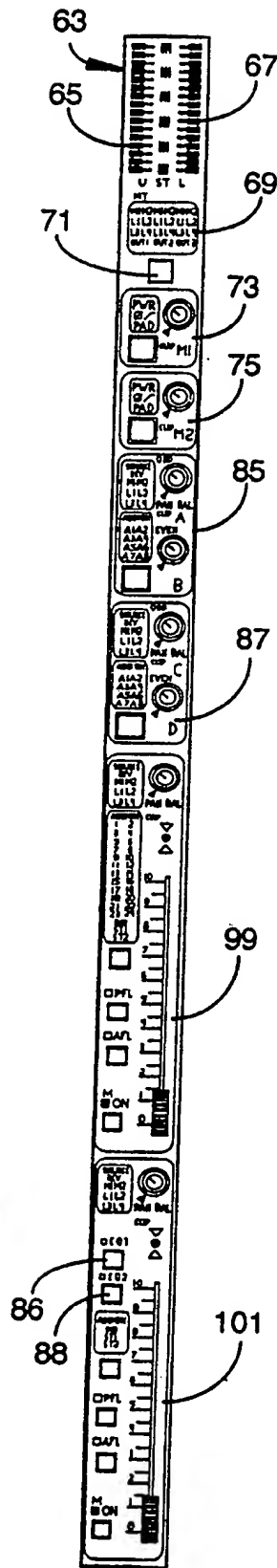


Fig. 3A

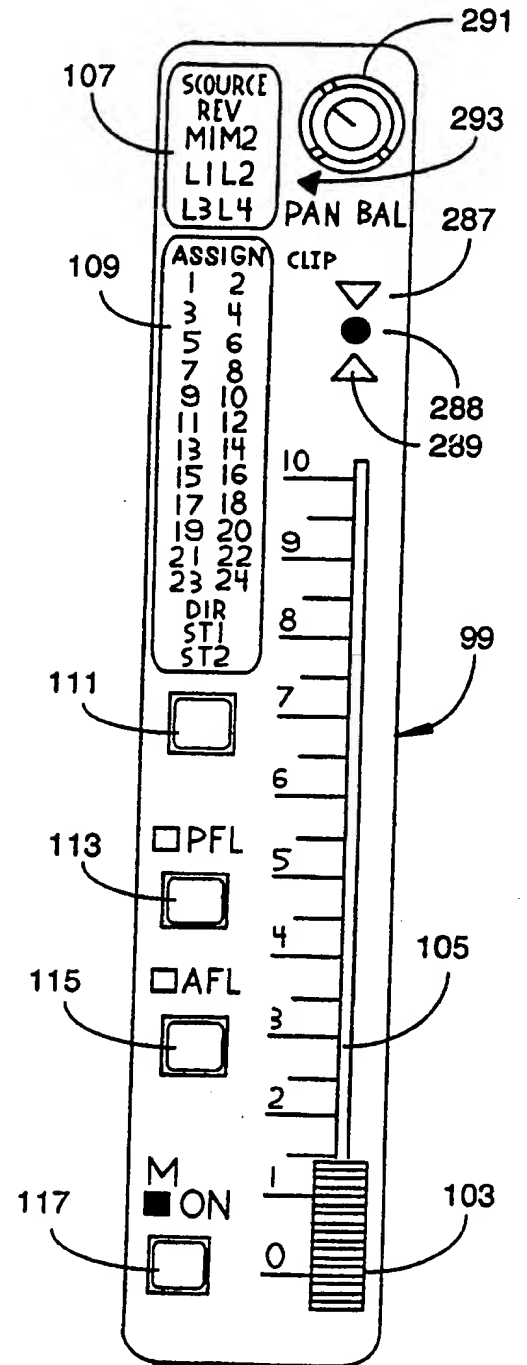


Fig. 3E

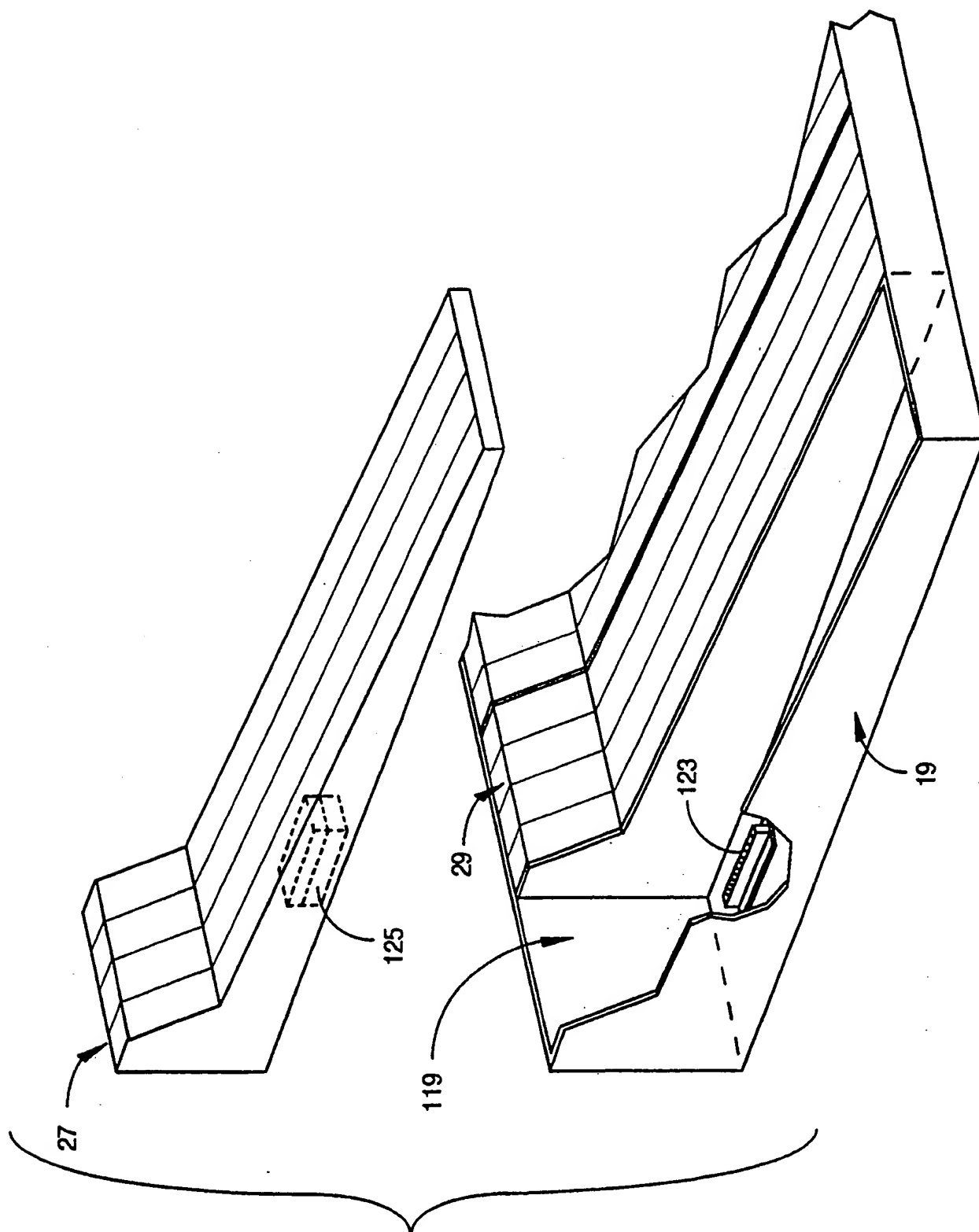


Fig. 4

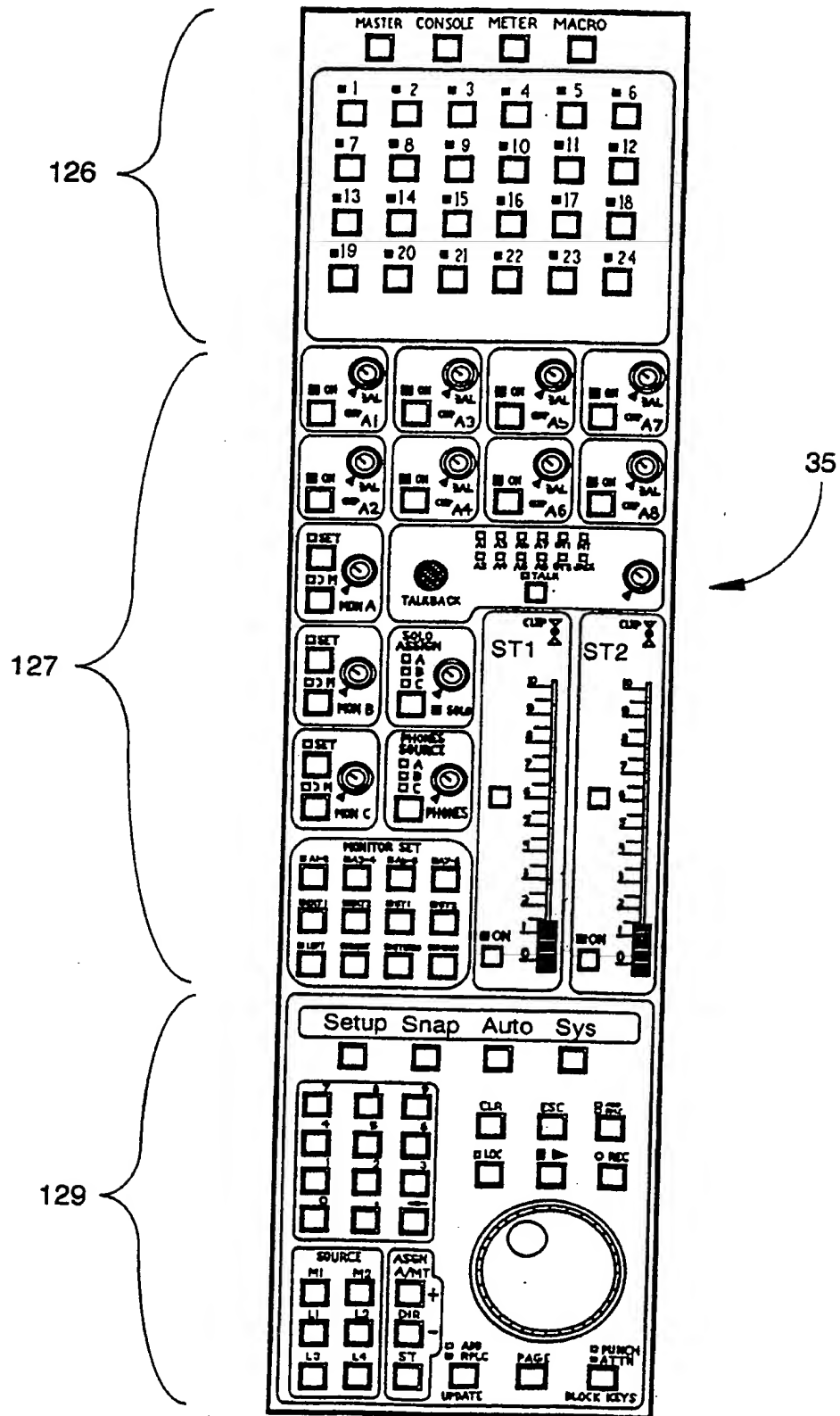


Fig. 5A

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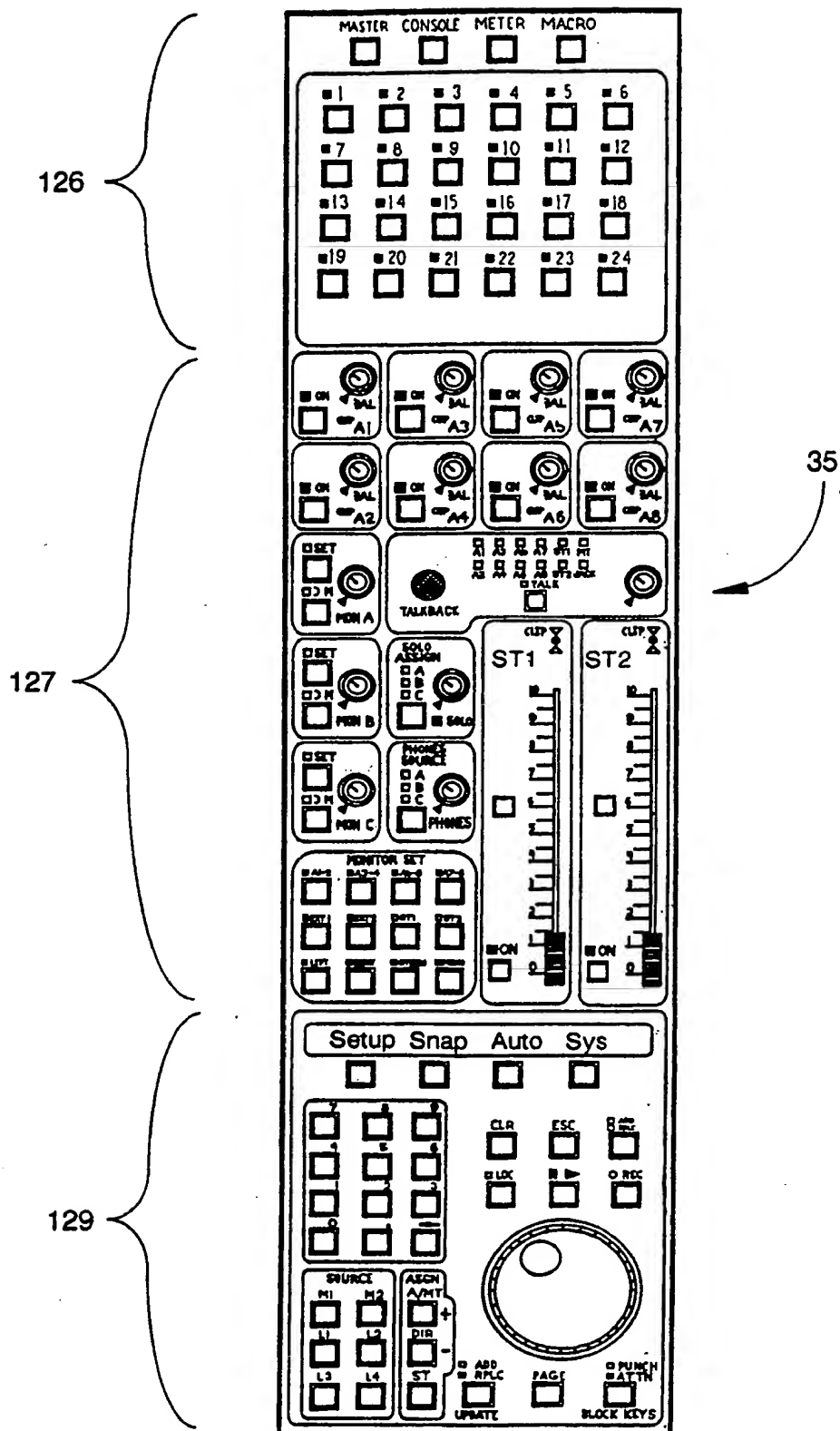


Fig. 5A

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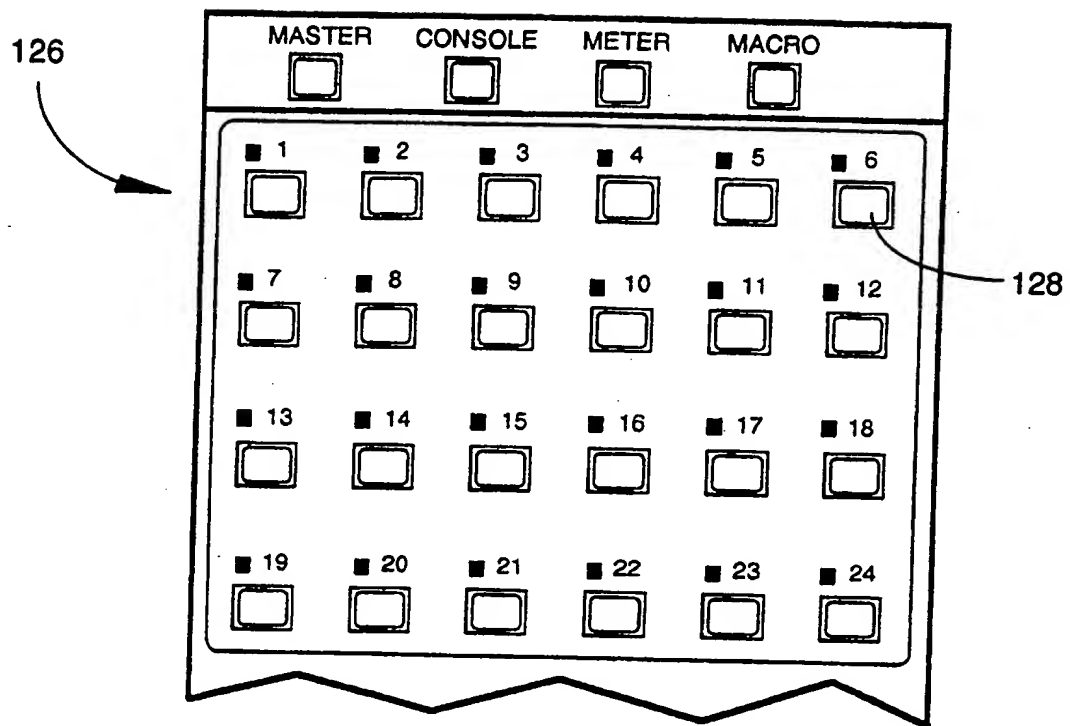


Fig. 5B

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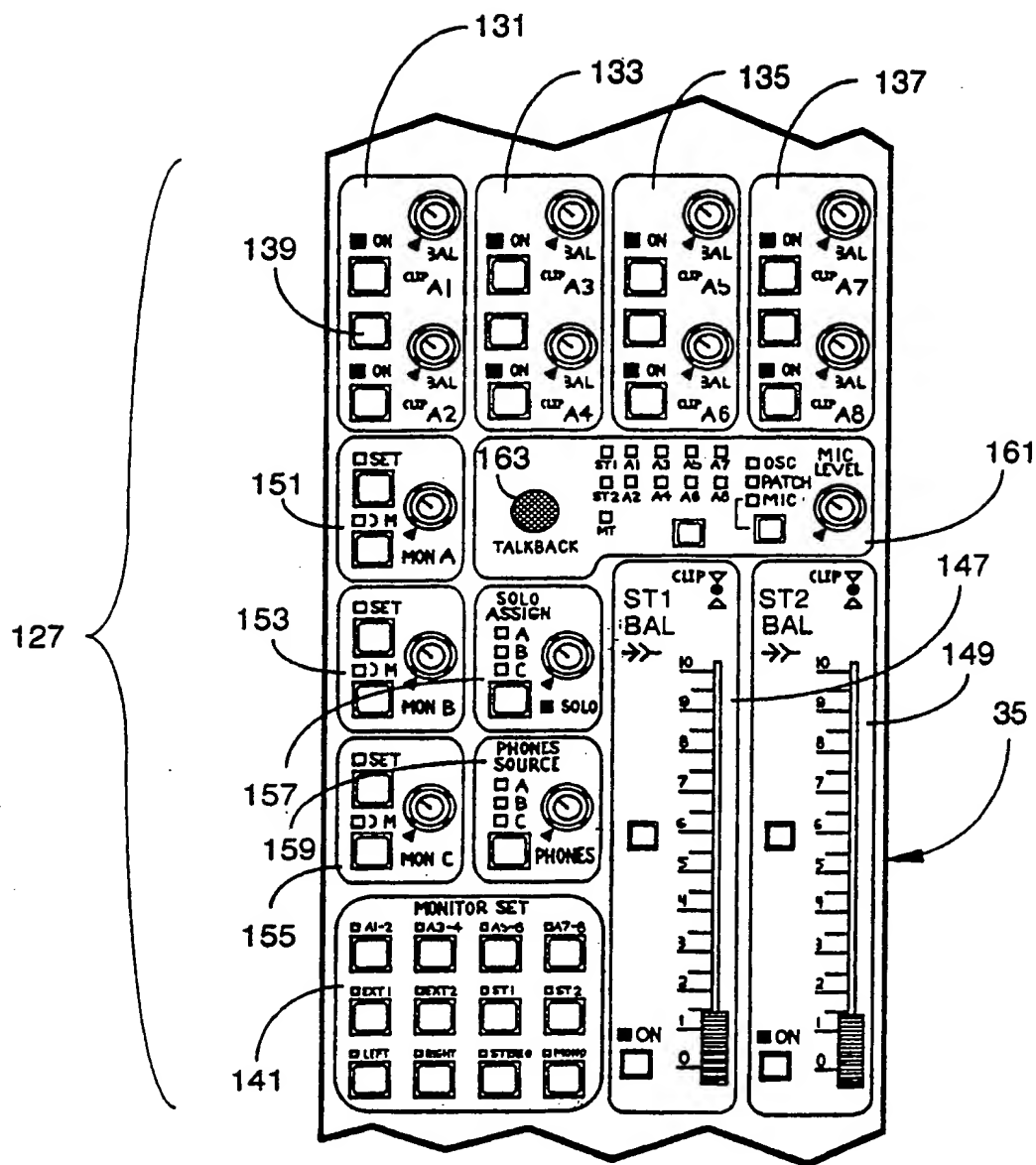


Fig. 5C

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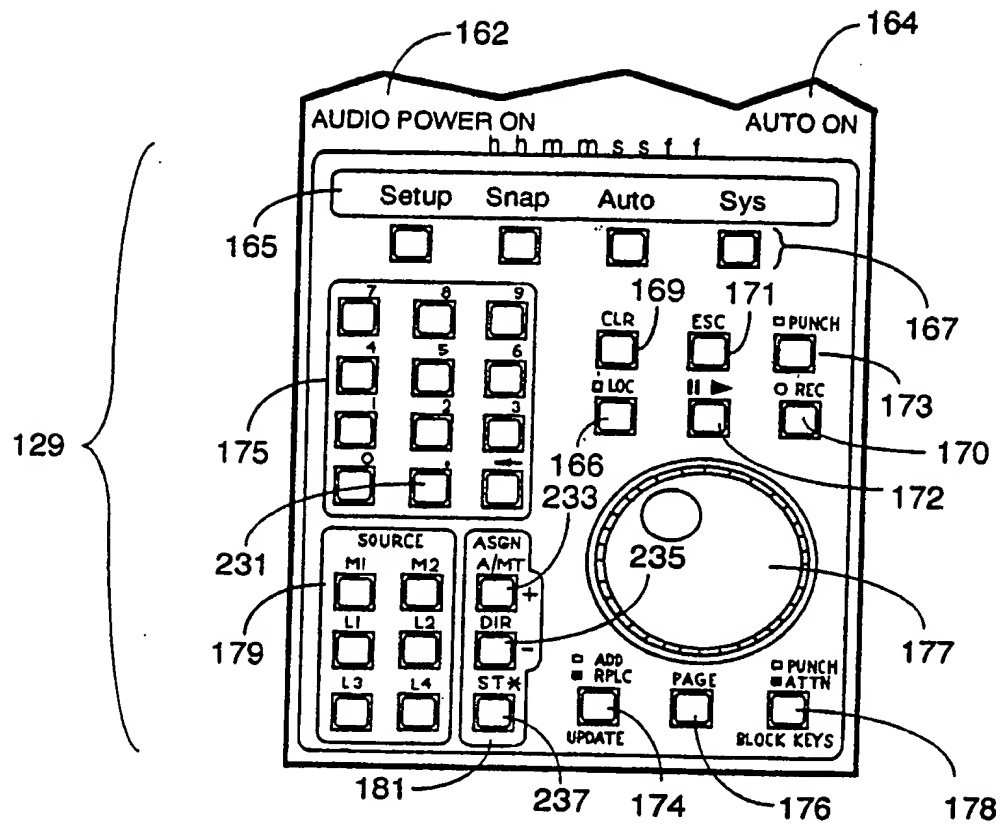


Fig. 5D



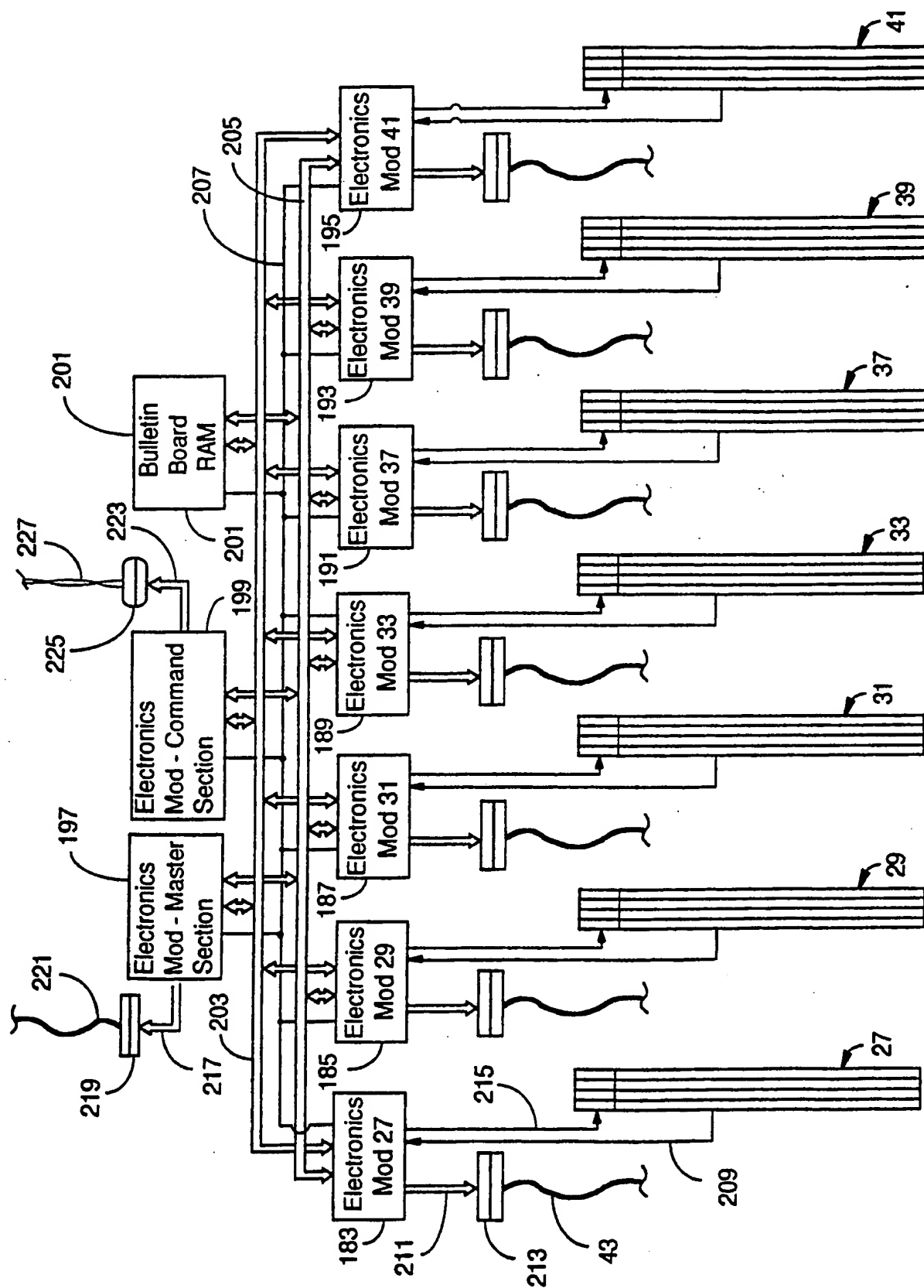


Fig. 6

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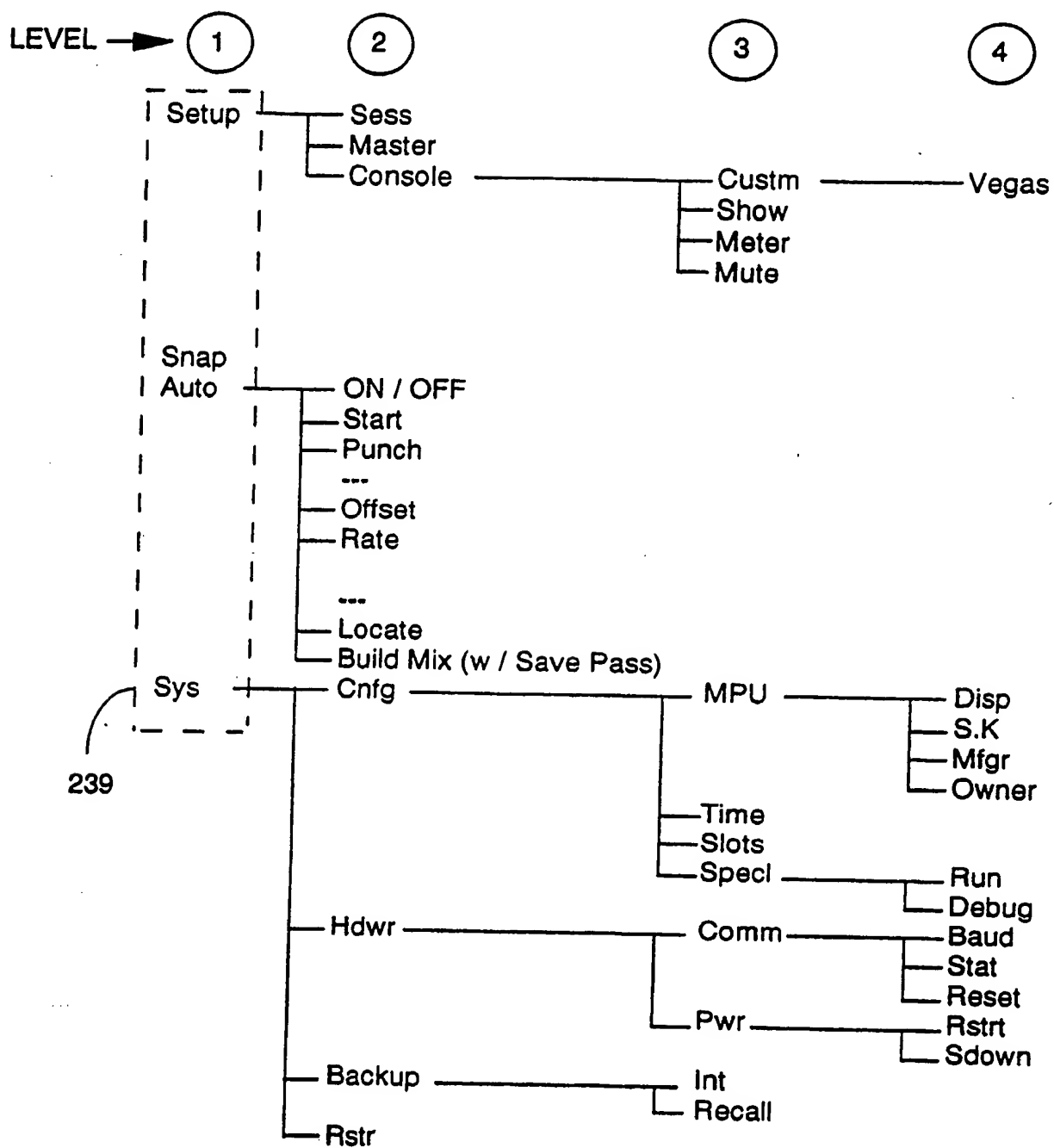


Fig. 7A

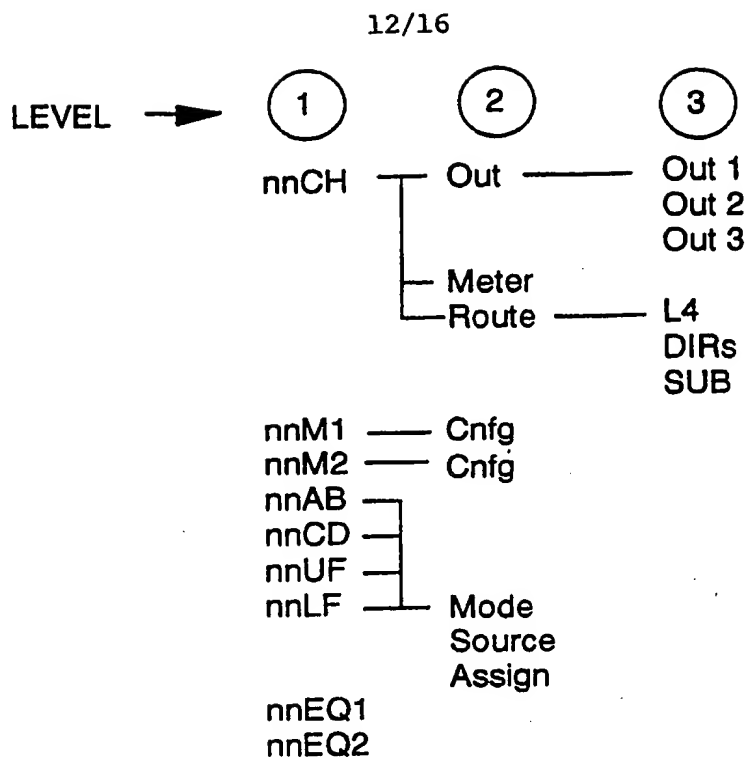


Fig. 7B

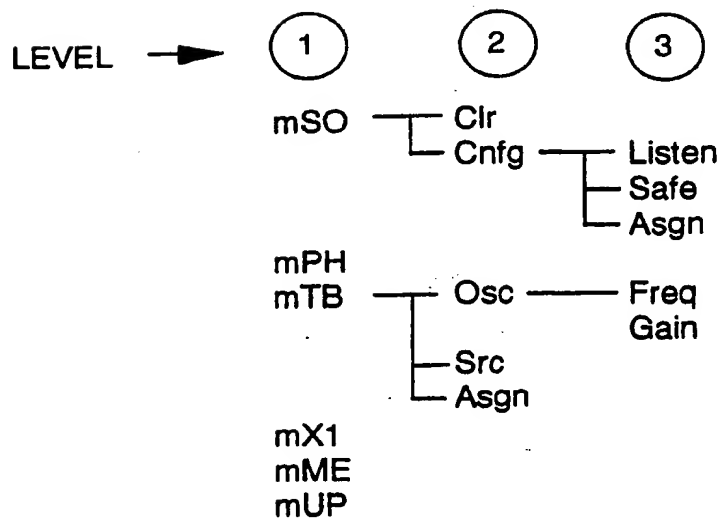


Fig. 7C

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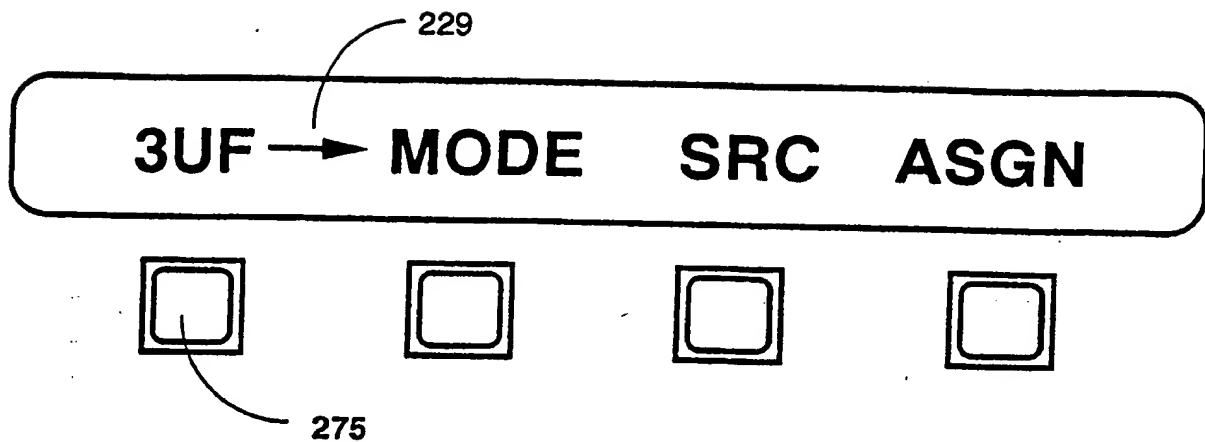


Fig. 8A

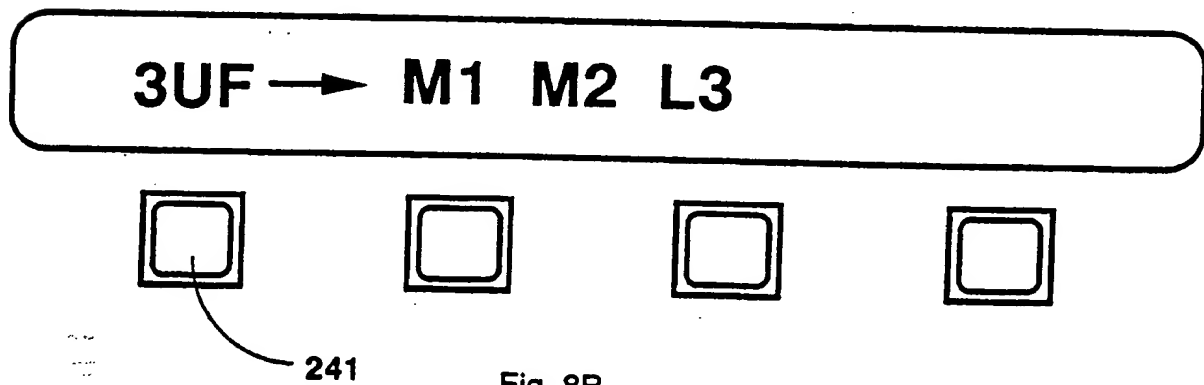


Fig. 8B

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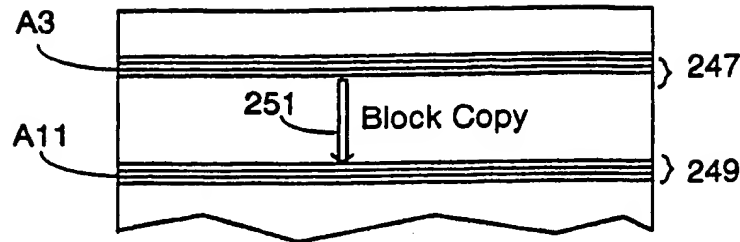


Fig. 10A

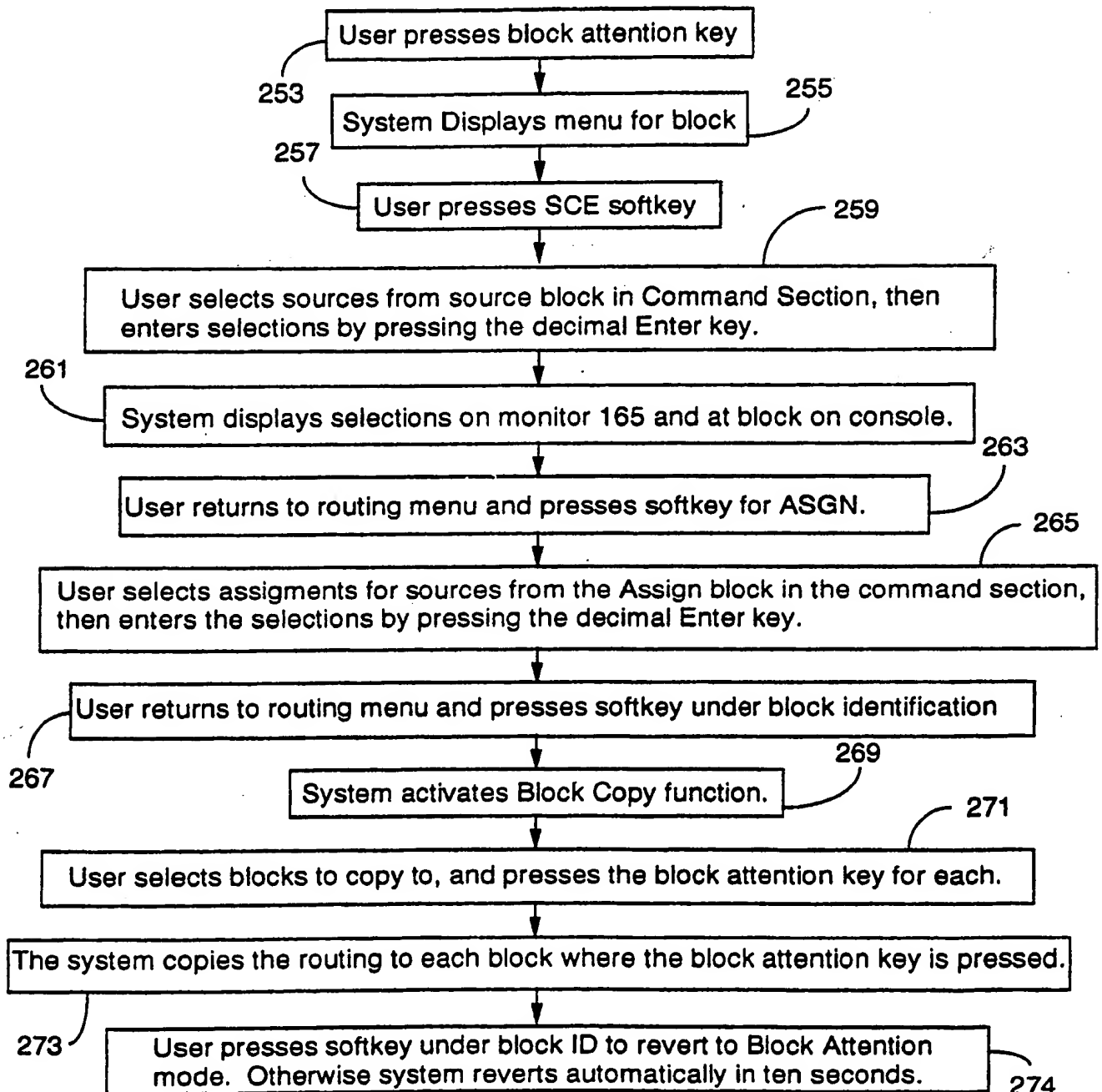


Fig. 10B

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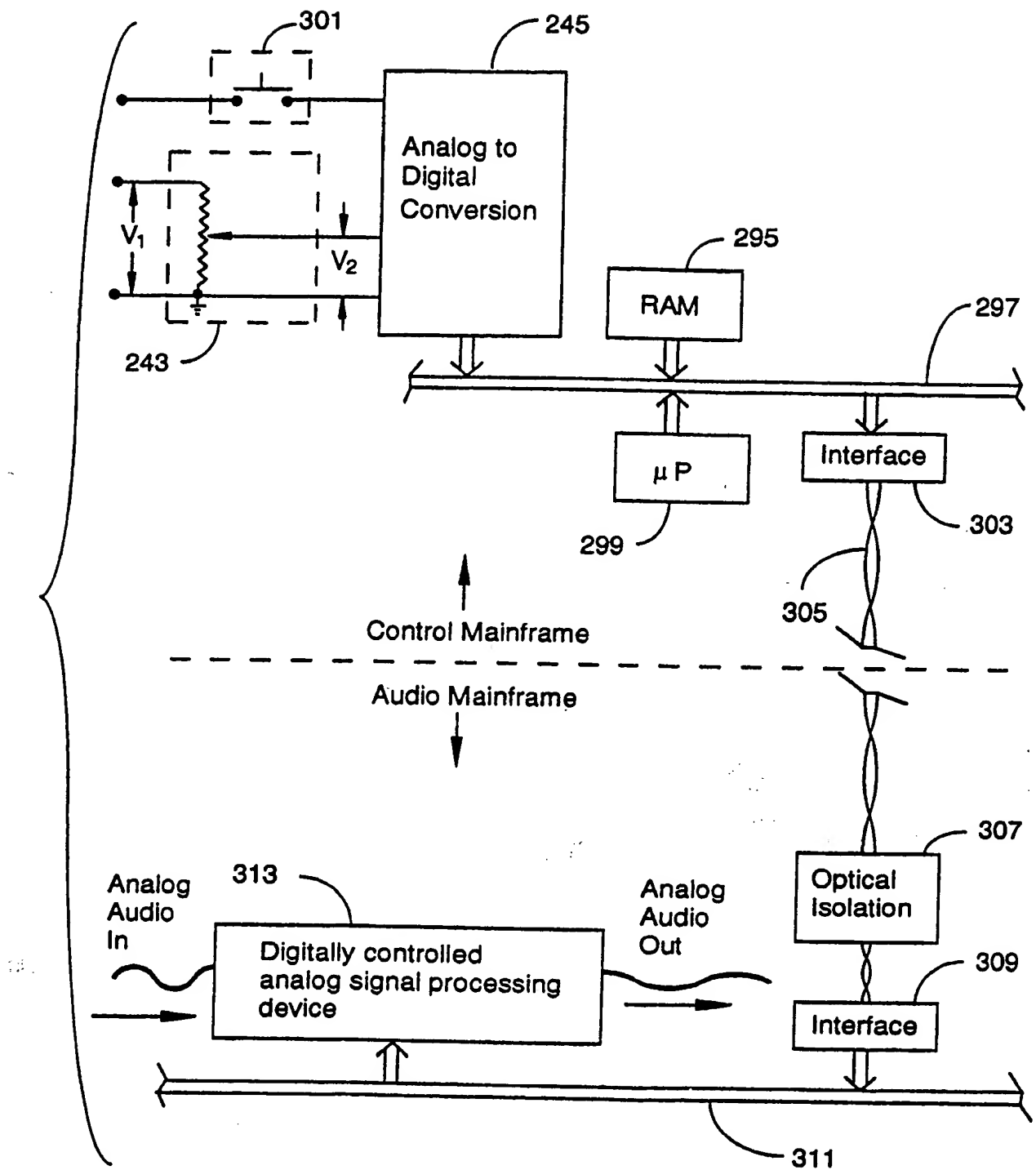


Fig. 9

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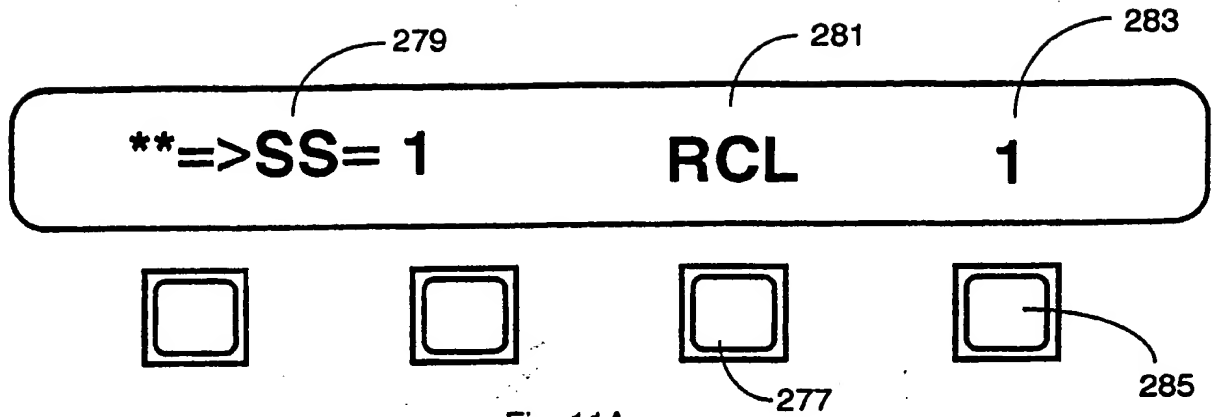


Fig. 11A

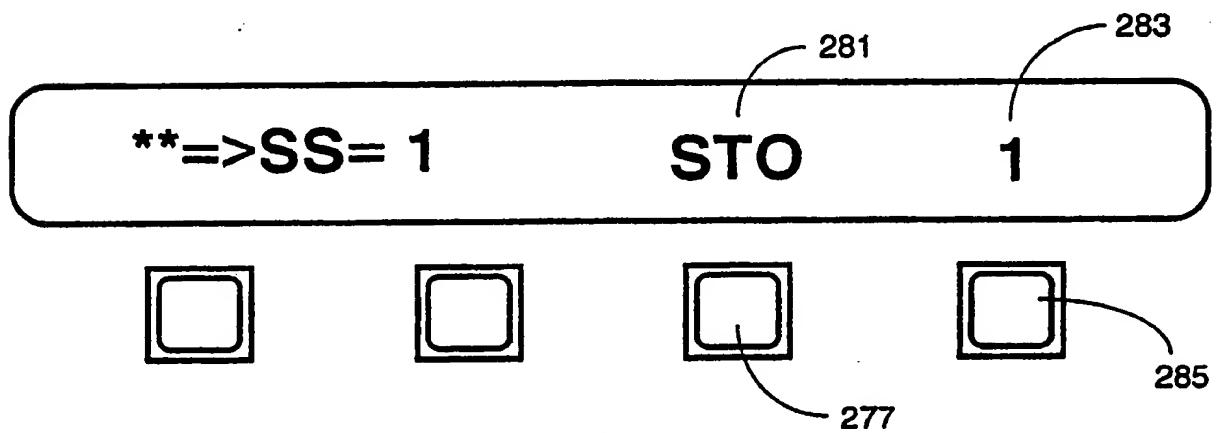


Fig. 11B

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US92/06229**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :HO4B 1/00

US CL :381/119

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 381/119

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
NONE**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	AUDIO ENGINEERING SOCIETY, MARCH 1982, RICHARDS ET AL., AN EXPERIMENTAL ALL DIGITAL STUDIO MIXING DESK, PG. 117-126	1,2 — 3-11
A,P	US,A, 5,060,273 (OLAH ET AL.) 22 OCTOBER 1991 SEE ABSTRACT AND FIGURES 1-3	1-11
A,P	US,A, 5,060,272 (SUZUKI) 22 OCTOBER 1991 SEE ABSTRACT AND FIGURES 1	1-11
A	US,A, 4,993,073 (SPARKES) 12 FEBRUARY 1991 SEE ABSTRACT	1-11
A	US,A, 4,479,240 (MCKINLEY, JR.) 23 OCTOBER 1984 SEE ABSTRACT AND FIGURE 1	1-11

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be part of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

01 SEPTEMBER 1992

Date of mailing of the international search report

27 OCT 1992

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